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ABSTRACT

This journal is intended for classroom teachers and provides a collection of essays and instructional materials organized around the theme of mathematics and science content knowledge. Articles include: (1) "Watching Ourselves Learn" (Annette Thorson); (2) "Search Smarter!" (Kimberly S. Roempler); (3) "Teacher Education Materials Project" (Joan Pasley and Thomas Gadsden); (4) "Researching New Ways To Serve You!" (Annette Thorson); (5) "Teachers Need a Special Type of Content Knowledge" (Zalman Usiskin); (6) "Do Not Forget Yourself as a Teacher of Yourself" (Terese Herrera); (7) "A Deeper Look at Elementary Mathematics" (Melanie Shreffler); (8) "Staying a Step Ahead" (Pamela Galus); (9) "ENC Can Help You Increase Your Content Knowledge" (Judy Spicer and Laura K. Brendon); (10) "Basic Skills and Conceptual Understanding: It's Not Either/Or" (Joan M. Kenney); (11) "NASA Reaches Out to Teachers" (Terri Payne Butler); (12) "Essential Science in Elementary School" (Sue Mattson); (13) "A Steep Learning Curve" (Tina L. Coplan); (14) "More Content Courses? Maybe Not!" (Paul Baker); (15) "Formulating Formulas: The Making-a-Mess Method" (Anne C. Patterson); (16) "Where Does 'Poly-Water' Come From, Anyway?" (Deanna Buckley); (17) "Turning Misconceptions into Teachable Moments" (Jennifer Gonya); (18) "Aspiring To Be a Teacher" (Judy Spicer and Michael Khoury, Jr.); and (19) "Did You Hear About...? What Does It Mean...?" (Susan Dahl). (MM)

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enc focus

A Magazine for Classroom Innovators

Volume 9, Number 3, 2002

Increasing Your Mathematics and Science Content Knowledge

No one can have all the answers—that is why teachers are lifelong learners.

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enc focus
Eisenhower National Clearinghouse
A Magazine for Classroom Innovators
Volume 9, Number 3, July 2002

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Increasing Your Mathematics and Science Content Knowledge

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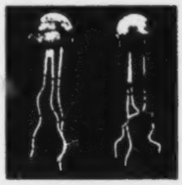

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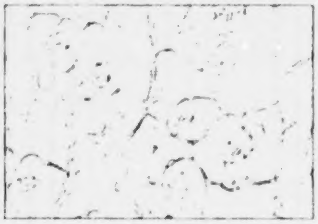

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Update...

Around the Clearinghouse and the Nation

This section features columns, essays, and news of interest to classroom innovators.

What is the Eisenhower National Clearinghouse?

Funded through a contract with the Office of Educational Research and Improvement of the U.S. Department of Education, ENC was created in 1992 to collect and catalog curriculum resources for K-12 mathematics and science educators and to disseminate information about federally funded educational programs. Our products and services have evolved to include a web site, ENC Online (enc.org); *ENC Focus*, a free quarterly magazine; and numerous other publications and services. For more information on ENC's vast collection of curriculum resources, see page 52.

Editorial

Watching Ourselves Learn

by Annette Thorson, ENC Publishing

In her classic work, *"The Having of Wonderful Ideas" and Other Essays on Teaching and Learning*, Eleanor Duckworth describes a scene in a teacher education course. Adult students, all with degrees in mathematics, were working with geoboards—square boards with 25 nails arranged in a 5 x 5 grid. The students were exploring shapes by stretching rubber bands around the nails:

> ...one student had set herself the problem of calculating the area of a triangle constructed on a base of three nails on the bottom row, having as an apex the first nail of the top row. Having calculated the area of that triangle, she moved the apex over one nail. To her great surprise, she found that the new triangle had the same area as the first. She then moved the apex over two more nails. Amazement—it was still the same area, and it remained the same area for all triangles on that base with apexes in the top row. Excited by her discovery, she announced it to the whole group. After considerable discussion, one member of the group realized that her discovery was none other than a "fact" that they had all "known" since elementary school: that the area of a triangle is half the base times the height. (p. 46)

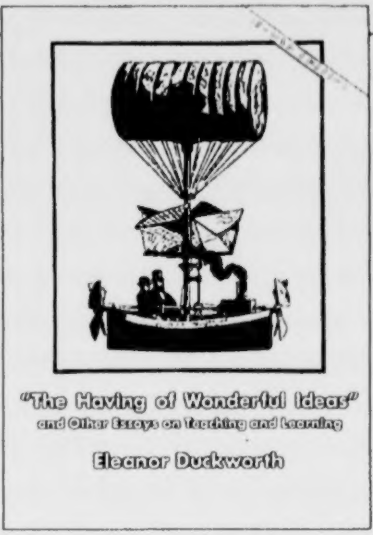
Duckworth comments, "...when we have learned something only in the form of a word or formula, we may not even recognize situations where this knowledge is pertinent." (p. 46).

Unfortunately, as we are all painfully aware, the majority of adults—even young adults—in this country grew up memorizing words and formulas, with very little chance to apply the learning. This has come back to haunt us as we try to teach inquiry and problem solving in our new, standards-based classrooms.

Duckworth's response to the problem is to give teachers the same hands-on experiences she recommends for children. She writes, "I think it is very important for teachers to have a chance to watch themselves learn" (p. 60). She tells the story of one group of teachers who spent two hours a day for four weeks studying electric circuits made only with batteries, light bulbs, magnets, and wires. Despite the seeming simplicity of the materials, the teachers realized they needed twice as much time to answer all their questions. Duckworth describes teachers rolling balls down ramps, keeping moon observation journals, thinking deeply about arithmetic problems—and then reflecting on how they learned.

This is the kind of learning teachers crave. More than a year ago, we asked ENC's teacher advisory group to choose among five possible topics for future issues of *ENC Focus*; they overwhelmingly selected Increasing Your Mathematics and Science Content Knowledge.

Zalman Usiskin, director of the University of Chicago School Mathematics Project, introduces the topic by explaining that traditional university mathematics and science courses are too narrowly focused to prepare teachers (page 14). He promotes the development of more "teachers' mathematics" and "teachers' science" courses—not courses with watered-down content, but courses providing the broad knowledge needed in the K-12 classroom. Usiskin's assertions are supported in the article "More Content Courses? Maybe Not!" which presents research from the University of Wisconsin (page 38).


"The Having of Wonderful Ideas"
and Other Essays on Teaching and Learning
Eleanor Duckworth

While teachers are intensely interested in the preparation of their future colleagues, their primary concern is how they themselves can become better teachers for their students. Renowned mathematics educator Liping Ma urges teachers "do not forget yourself as a teacher of yourself" (page 16), and that is the message of every article in this issue.

Deanna Buckley reflects on what she learned when a former student became her lab partner in a graduate biochemistry course (page 43). Calculus teacher Denise Tabasco moved from number crunching to real understanding when she was required to use a new reform-based curriculum (page 35). Pamela Galus describes the challenge of keeping up with her students when she let them take the lead in her Earth science class (page 22). Joan Kenney presents examples of the types of mathematics problems that not only help students learn, but build teachers' own understanding of math concepts (page 26).

For teachers who worry about gaps in their own knowledge, Jennifer Gonya shows how to turn misconceptions into teachable moments (page 46). Anne Patterson describes a "making-a-mess" method of learning geometry that is just as effective for teachers as it is for students (page 40).

Some of the articles describe resources that will help you increase your content knowledge. Susan Dahl of the Lederman Science Education Center of Fermi National Accelerator Laboratory shares her favorite resources for staying up to date in science (page 50). Another article shows how teachers benefit from two NASA television series that engage their students while providing support for their own learning (page 30). Another describes a free telecourse from the Harvard-Smithsonian Center for Astrophysics that will help elementary teachers build their science knowledge (page 33). ENC staffers Judy Spicer and Laura Brendon present mathematics and science entries from Classroom Calendar, a growing source of content knowledge available free via ENC Online (page 24).

We wanted this issue of *Focus* to give you ideas on how you can increase your content knowledge, but we did not want to stop there. We wanted you to actually increase your content knowledge—if only a little bit. That is why we asked authors to provide specific examples of math or science content, related to their story, that they thought would be of interest to you. Perhaps one of these examples will give you the opportunity to watch yourself learn.

In addition to her background as an editor of educational magazines, Annette Thorson has taught in classrooms ranging from kindergarten through college. She encourages readers to contact her with comments about ENC Focus. *Email: athorson@enc.org*

Reference

Duckworth, Eleanor. (1996). *"The Having of Wonderful Ideas" and Other Essays on Teaching and Learning* (2nd ed.). New York: Teacher's College Press.

Eleanor Duckworth worked with Jean Piaget for more than two decades, serving as his English translator when he lectured in North America. She is a professor in the Graduate School of Education, Harvard University.

ENC invites readers to contribute articles to ENC Focus: A Magazine for Classroom Innovators.

Join in the Dialogue! *Write for* ENC Focus

Topics and Deadlines:

Special-Needs Students in the Mathematics and Science Classroom - Submissions due September 1, 2002

Collaborating with Colleagues to Improve Practice - Submissions due December 1, 2002

Using Technology to Learn Mathematics and Science - Submissions due March 1, 2003

Topics and deadlines subject to change without notice.

See Writers' Guidelines on page 10.

Search Smarter!

Refinements and additions to search engines make the World Wide Web a better source of information for students.

by Kimberly S. Roempler, ENC Instructional Resources

In the last issue of *Focus* (Mathematics and Science Across the Curriculum, Vol. 9, No. 2), Joyce Kasman Valenza wrote about the limitations of the widely available search engines for student research. Students miss important resources when they use the World Wide Web as their only source of material. I couldn't agree more. However, using the right search engine will help students uncover important resources that will support research projects.

Over the last few years, search engines have refined their advanced searching capabilities and increased the options that users have before they even begin their searches. A variety of search engines have been developed that index only one discipline, such as science, or one resource type, such as newspapers or audio files. Several search engines have been developed especially for children.

Indexes and Directories

Search engines fall in two main types—ones that automatically index web resources (like Google) and directories (like Yahoo!) that depend on humans to do the indexing. Some search engines return results that are a mix of the two types. Both provide useful results for student research. Web pages that are indexed automatically are "spidered" or "crawled" by software that visits the page, reads it, and follows links to other pages. Everything that is "read" is indexed. The search engine plows through the index and finds matches to search queries. The engine may present the matches ranked by the number of times the search term shows up in the web page or in the links from that specific page.

Because "spiders" don't "read" all the same web pages or revisit sites in a timely fashion, the same search query used in different search engines will return different results—some more relevant than others.

Meta Search Engines

A third type of search engine doesn't spider the web to build indexes. Instead, this search engine searches the result sets from other engines. It returns the matches from several other search engines all at once, saving the searcher from having to visit each major search engine individually.

An example of this third type is IxQuick, which searches 13 different engines and identifies the engines where it located a particular site. The return list is manageable, with only 70 to 80 resources returned for each query. However, IxQuick accepts money to make sites appear at the top of return lists. These sites are labeled as "sponsored," so be aware of this feature. Vivisimo, another example of this type, sends queries to a variety of search engines and organizes the output of these search engines. A unique feature of Vivisimo is that it returns resources in clusters or categories.

Advanced Searching Capabilities

One of the most useful advanced searching capabilities that engines like Google, Alta Vista, and FAST offer is safe-search filtering. These filters screen out objectionable material. For example, Google's SafeSearch screens for sites that contain offensive content and eliminates them from search results. While no filter is 100 percent accurate, Google's filter checks keywords and phrases, URLs, and categories.

Filtered search engines allow students to search the entire web rather than a handpicked selection of kid-safe sites. This feature allows teachers to give their students access to major search engines that teachers were not comfortable with previously.

Many advanced search features include the ability of search engines to handle wildcards, Boolean searching, and a number of languages. Wildcard searching is helpful when you aren't sure how a word or phrase is spelled or what version of the word might be used. An asterisk is used in place of the letter or word you don't know (e.g., environment* would search for environmental as well as environment). Boolean searching allows the user to broaden or limit searches by adding the commands *and*, *or*, and *not* to the keywords. The language feature in advanced search allows users to limit searches to materials in one language or expand to all languages.

DISCUSS

ENC is hosting an online discussion of this article. Join other educators talking about questions such as these:

- How has the web affected your students' research?
- Has the impact been positive or negative—or both?
- Should traditional research methods still be taught?

Visit enc.org/focus/content/discuss

Specific Search Engines

Some information in databases is not available to the search engines' indexing mechanisms. The information that is locked away in these databases has been called the "invisible web." Specific search engines have been developed to search these hidden databases.

A relatively new engine, introduced in 2001 and called Scirus, indexes web resources that are specific to the domain of science. The Yahoo! News search engine spiders only news sites and revisits these sites several times a day. If you want to access only images, use the Google Image search or the Alta Vista Photo Finder. Advanced searching allows choices to be made in terms of image size, file types, and color. You can also search for all media—images, video, or audio—by using the FAST Multimedia search engine. Advanced search features include choosing stream or download, the file type, format type, and channel for audio files.

Kid-Safe Search Engines

In the search engine Ask Jeeves for Kids, children can type in a question just like they would ask a teacher or parent. The engine's developers have created appropriate answers to a wide variety of questions. If an answer isn't found, Ask Jeeves pulls results from other search engines just as a meta search engine does. The returns from each of the search engines are filtered before the list is returned to the user. This is different from the Yahooligans site, which provides hand-picked sites appropriate for children. If there are no matches from within the Yahooligan index, searches will not be forwarded to the Yahoo search engine. Additionally, adult-oriented banner advertising will not appear within the service.

The Bottom Line

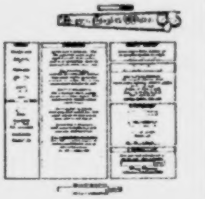
The best advice to teachers is to become familiar with the many indexes, directories, and meta search engines that are available to you and your students. Always click on the "advanced" or "customize" buttons when visiting search engines to see what features are available. Pick a few keywords or phrases and systematically run the same search on each search engine. Compare the results to see which engines return material that is relevant to your purposes. Have your students do the same exercise. Have them analyze the results and present their findings to the class. A lively discussion almost always follows.

Kimberly Roempler is the associate director of Instructional Resources, ENC, and director of The Learning Matrix, the National Science, Mathematics, Engineering, and Technology Education Digital Library initiative at ENC. Email: roempler@enc.org

Roempler's Recommended Resources

General Information

- Web Searching Tips—www.searchenginewatch.com/facts/index.html
- Search Engine Watch—www.searchenginewatch.com
- A Helpful Guide to Web Search Engines from Spider's Apprentice—www.monash.com/spidap.html



- Kid's Search Tools—www.kidsclick.org/ksearch.html
- Search Engine Showdown Internet Search Strategies—www.notess.com/search/strat

Indexes

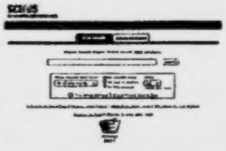
- Google—google.com
- Alta Vista—www.altavista.com
- FAST—www.alltheweb.com

Meta Search Engines

- IxQuick—ixquick.com/eng
- Vivisimo—vivisimo.com/html/index.html

Specific Search Engines

- Invisible Web—www.invisibleweb.com
- Scirus for Science—www.scirus.com
- Yahoo News—news.yahoo.com



- Alta Vista Photo Finder—www.altavista.com/sites/search/simage
- Google Image Search—google.com/imghp?hl=en
- FAST Multimedia Search—multimedia.alltheweb.com

Kid-Safe Search Engines

- AltaVista Family Filter is www.altavista.com/sites/search/ffset
- AOL for Kids—webcenter.search.aol.com/kids
- Ask Jeeves for Kids—www.ajkids.com
- Yahooligans!—www.yahooligans.com

Search Engines Ratings

Two web sites rate search engines for the quality of their services to users. Recent ratings can be found here.

2001 Search Engine Watch Awards—www.searchenginewatch.com/awards/2001-winners.html

Spider's Apprentice—www.monash.com/spidap.html

Teacher Education Materials Project

The result of this partnership is a web site devoted to helping professional development leaders locate the best resources to challenge, support, and guide teacher learning.

by Joan Pasley, Horizon Research, Inc., and Thomas Gadsden, ENC Collaboration

Whether professional development consists of self-guided work or large-scale staff development, implementing change in teaching and learning requires ready access to resources that challenge, support, and guide teacher learning. The Teacher Education Materials Project (TE-MAT) provides that access.

TE-MAT

When Horizon Research, Inc., received a grant from the National Science Foundation to create TE-MAT, the organization established a partnership with ENC. The collaboration has resulted in a unique web site (te-mat.org) devoted to helping professional development leaders locate the optimal resources for their purposes.

Expert Reviewers

Horizon Research brought together many of the nation's top mathematics and science professional developers to provide guidance in identifying materials. The advisors were also asked for their suggestions for online resources that should be developed by the project to provide support for both the novice and the expert professional developer.

In addition, Horizon enlisted these professional developers and other leaders (a total of about 230 educational

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Sample TE-MAT Review

Here is just one sample of the more than 400 reviews available on the Teacher Education Materials Project web site (te-mat.org). It was selected for this issue of *ENC Focus* because the resource described would help teachers increase their content knowledge.

Physics by Inquiry, Vol. 1 and 2: An Introduction to Physics and the Physical Sciences

by Lillian C. McDermott with Peter S. Shaffer and Mark L. Rosenquist and the Physics Education Group, University of Washington. New York, NY: John Wiley & Sons, Inc., 1996.

I. Description of Material

Physics by Inquiry is a set of introductory, laboratory-based modules for physics and the physical sciences appropriate for use with both preservice and inservice K-12 teachers. The modules have an extensive research base.

II. Purpose and Audience

The author states that "*Physics by Inquiry* is particularly appropriate for preparing pre-service and inservice K-12 teachers to teach science as a process of inquiry" (p. iii). The primary emphasis of the course is on learning by discovering rather than by memorizing, and on teaching by questioning rather than by telling. "The modules have been explicitly designed to develop scientific reasoning skills and to provide practice in relating scientific concepts, representations, and models to real world phenomena" (p. iii).

III. Content and Quality

Volume I begins with an emphasis on the fundamentals of science, namely a sound and logical development of some of the science process skills, while exploring scientific reasoning. Constructing operational definitions as part of measuring matter is very explicitly developed as part of doing science in this volume.

The material included in Volume II provides a foundation for the study of introductory physics and includes topics in electricity, electromagnets, light and optics, kinematics, and astronomy by sight. Of these, only astronomy by sight and electromagnets are dependent on Volume I.

The text contains narratives that include facts, definitions, and examples of common student reasoning, exercises and experiments designed to actively engage the learner, and supplementary problems that can be used for additional practice. Participants are also encouraged to keep individual notebooks for recording and reflection.

Extensive research by the University of Washington Physics Education Group on how students think and learn preceded the development of these materials and is reflected in their design. Consequently, the disciplinary and pedagogical content is sound, coherent, and rigorous. For example, in the section on principles of balancing, participants are asked to describe an experiment to find out whether temperature change influences the growth of tomatoes. Controlling variables, uncertainty of measurements, and proportional reasoning with mass and volume are highlights of the early part of these experts) to do peer reviews of each resource identified and to provide suggestions for the effective use of the material. Every resource is reviewed by at least two people with expertise in mathematics or science and professional development. The results of these expert reviews of more than 400 professional development materials are now available at te-mat.org. See the sidebar below for a sample TE-MAT review.

A Searchable Database

To provide ready access to the TE-MAT reviews, each professional development resource has been described and catalogued by ENC, and these records and reviews are accessible online in a searchable database. The search criteria for the database were specified by Horizon Research to reflect the unique needs of professional developers.

For example, using the Descriptor Search, a professional developer can select the teacher grade-level bands (such as K-5 or 9-12), subject (mathematics), topic area (number and operation), the author's stated purpose (for example, deepening teacher content knowledge), and special features (such as student products or research). The professional developers can refine their search even more by entering their own particular key terms.

The Keyword Search has fewer categories from which to select, but it encourages users to enter several more specific terms (such as fractions or disabilities) that will help in the search for appropriate materials. Additionally, the TE-MAT Materials Index provides a list of all of the materials reviewed in the database, organized alphabetically both by title and by author.

The reviews found in a search describe not only the material but also its purpose and intended audience, its content and quality, ideas for using the material, and comments and cautions concerning its use. Bibliographic information—including grade levels, table of contents, cost, and availability—is available at the click of a button.

continued on page 10

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materials that help lay the foundation upon which to build the rest of the course. Interpretation of numbers and graphs is also addressed in meaningful context early in the course.

The Physics Education Group has published many articles documenting that the *Physics by Inquiry* approach is effective in promoting conceptual understanding. This method has consistently produced superior conceptual understanding when compared to the traditional lecture-laboratory courses typically taught at universities and colleges across the country. The researchers have identified the misconceptions typically held by students and then designed learning experiences that incorporate guided inquiry to lead the student to make observations that conflict with those misconceptions. Thus, the student is stimulated to construct more scientifically correct models to explain common phenomena.

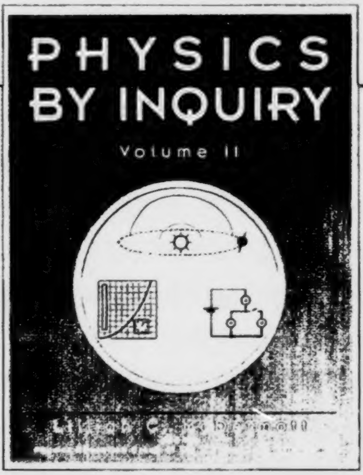
These materials are well designed to cultivate scientific reasoning and conceptual development of physical science ideas. They provide a valuable resource for professional development that both engages participants in inquiry and addresses areas of content in which teachers are often inadequately prepared.

IV. Reviewers' Ideas for Using this Material

Reviewers noted that these materials could be used as intended for inservice workshops for classroom teachers. There are modules that would be appropriate for workshops of several days' duration. Topics include: heat and temperature, light and color, magnets, electric circuits, and electromagnets. Another option would be to use these materials in a professional development program that is spread over a year, requires intermediate assignments, and begins and ends with full-day workshops actually using the *Physics by Inquiry* materials.

Another potential professional development use is with teachers of teachers, both university faculty and professional development providers. This audience might need additional sessions to discuss the importance of this approach and how it relates to what is known about effective teaching and learning.

The *Physics by Inquiry* volumes would be best used by a knowledgeable professional development provider who understands the research on which they are based. There should be sufficient time allowed so that learners can work through the activities, reflect together on the method of instruction, and discuss how to apply these ideas to their classrooms.



V. Comments and Cautions

Some professional development providers may want to enhance the materials by allowing participants to design experiments and collect data to help them answer questions of their choosing.

A Conceptual Framework

According to Iris Weiss, president of Horizon Research:

> Effective professional development does not just happen. To create high quality professional development programs, designers must understand the needs of their target audience; know what research and the wisdom of practice have to offer; address multiple goals within the constraints of limited resources and the realities of specific contexts; implement activities consistent with their goals; and continually monitor and fine tune the program to best address their professional development goals.

To help the professional developer accomplish all of this, te-mat.org includes a Conceptual Framework that addresses each of the issues listed above. The framework provides guidance in selecting the right materials for a specific purpose and in designing the professional development experiences for optimum growth.

In addition, throughout the Conceptual Framework are links to reviews of materials that are examples of the point being discussed and to practitioner essays in which experienced professional developers share reflections about their work. The essays examine topics such as gender equity, student thinking, assessment, development of teacher leaders, and evaluating professional development programs.

What Is Next?

Weiss points out that identification, review, and entry of materials into the TE-MAT database will continue through the remainder of the project, which is scheduled to end in March 2003. Beyond that point, the database itself will be maintained by ENC as part of its ongoing dissemination work in science and mathematics education and professional development.

Weiss notes, "In the final year of the project, TE-MAT staff are analyzing the database to identify gaps in materials available to professional development providers. Results of the analysis will be shared with members of the mathematics and science education communities, including NSF and other groups that provide funding for materials development."

Other plans include a major convocation on professional development design and implementation related to the TE-MAT database. Scheduled for September 29-October 1, 2002, in the Washington, D.C., area, the meeting will involve mathematics and science educators and staff development specialists from school districts and state levels, as well as from public and private colleges and research and development organizations.

Joan Pasley is the TE-MAT project coordinator at Horizon Research. Thomas Gadsden is associate director for collaboration at ENC. Email: tgadsden@enc.org

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Writers' Guidelines for *ENC Focus*

Detailed Writers' Guidelines are available online at

enc.org/focus/write

Here are Guideline highlights:

Articles submitted for consideration should be grounded in the national educational standards while being short (500 to 2,000 words) and compelling. It is essential that articles promote educational equity and advance the principle of "education for all." We particularly invite teachers to write about their classroom experiences, using first person and a conversational tone. Please note that library research papers written in academic language for graduate school courses are unlikely to be selected for publication. We do, however, encourage you to include a few, carefully chosen references or a brief reading list. All content must be original, and all quotations must be properly cited. ENC is not interested in publishing articles that have the main goal of promoting commercial products.

Photos or other illustrations add interest, and good illustrations increase your chances for publication. Students in laboratory settings must be shown following appropriate safety guidelines and wearing proper safety attire, including eye protection. Please note that we can use photos of children under 18 years of age only if we receive written permission signed by a parent or guardian.

Authors of unsolicited manuscripts are urged to send a brief proposal via email well in advance of the deadline for the upcoming topic. We prefer that manuscripts be submitted electronically. Each manuscript must be accompanied by the full names, postal addresses, telephone numbers, and email addresses of all authors.

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Researching New Ways to Serve YOU!

by Annette Thorson, ENC Publications

"I used ENC products to educate and inform department members of current ideas and best practices in mathematics education."

"As a science coordinator, I have recommended the use of enc.org to teachers and teacher committees working on school improvement plans in math and science."

"The curriculum resources in *ENC Focus*: New Horizons in Mathematics and Science Education and *ENC Focus*: Becoming Literate in Mathematics and Science helped me acquire the 'best of the best' for my classroom. The articles have helped me better understand inquiry-based teaching and how to implement it in my classroom."

"I am a special educator—adaptation is the key to my lesson planning. ENC helps me gain new insights on how to help my students access knowledge."

"*ENC Focus* magazines have fostered discussion between our school's math and science departments and have been a focus of a science department meeting."

"I am currently teaching geometry to a blind student, I am an advisor for our school's robotics team, and my own child is in first grade. ENC products help me determine how to make changes in each of these challenging tasks."

"Bureaucratic inertia is difficult to change. I used ENC's publication *Ideas That Work: Science Professional Development* to argue for a greater variety of professional development.... and won!"

The comments in the sidebar are just a few of the ones ENC received in a scientific survey of a random sample of 92,254 educators who requested ENC publications in 2001. We received a lot of good news in the survey. For example, 95 percent of the total respondents perceived ENC products to be easy to access, up to date, easy to use, and relevant to their careers.

The formal survey was only one effort in ENC's continuing quest to assess how we are doing and to find ways to better serve educators. For example, we say *ENC Focus* is a magazine for classroom innovators, but we had not researched exactly how that description fit our subscribers. An informal survey printed in the October 2001 issue of *Focus*, and also made available on ENC Online, asked readers which of the following list of characteristics of classroom innovators fit them:

- Attend education conferences
- Read a professional journal or other professional materials
- Collaborate with teachers in their buildings on projects or professional activities
- Try new ideas in their classrooms
- Visit or observe other classrooms
- Analyze assessment or survey data from their classes or school
- Assume leadership responsibility in their schools

No one at ENC was surprised to learn that the vast majority of *Focus* readers are indeed functioning as classroom innovators. For example, 93 percent read professional journals, 88 percent attend conferences, and 86 percent collaborate with teachers in their buildings on projects and assume leadership responsibilities in their schools.

This finding was especially interesting when we consider the results of another of our research efforts. This time, instead of long-distance surveys, we talked directly to groups of teachers in three cities. And instead of relying solely on verbal communication, we asked teachers to make collages illustrating their lives as teachers and how professional development fits in.

We learned a great deal from this research, but two findings, while not surprising, stood out:

- The boundary between home and school is blurred for most teachers, and most indicated that sufficient time to explore, plan, and reflect comes only twice a year, during the summer and the winter break.
- Teachers rely extensively on other teachers in their schools and districts for information, ideas, and resources.

To respond to these two pieces of information, ENC made a couple of decisions. This summer, we are offering a free online course based on our electronic publication *By Your Own Design: A Teacher's Professional Learning Guide* (visit enc.org/pdguide). We also decided we need an issue of *Focus* devoted to collaborating with the teacher across the hall. (Deadline for articles is December 1, 2002. See page 10 for submission guidelines.)

Of course, our response to all our research goes far beyond these two decisions. We are engaged in an ongoing inquiry into the ways we can better serve you. You can help us add depth to our research by telling us what you think. Email editor@enc.org

Annette Thorson is the editor of ENC Focus. *Email: athorson@enc.org*

Improving Mathematics and Science Education

EISENHOWER NETWORK

ENC is part of the National Network of Eisenhower Regional Consortia and Clearinghouse, a nationwide collaboration that provides support to mathematics and science educators across the country. In addition to ENC, the Eisenhower Network includes ten Eisenhower Regional Consortia that work toward these goals:

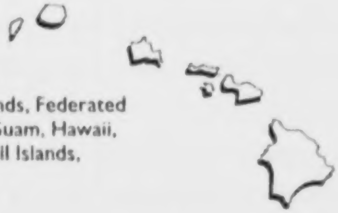
- To identify and disseminate exemplary mathematics and science instructional materials;
- To provide technical assistance to educators in implementing teaching methods and assessment tools;
- To collaborate with local, state, regional, and national organizations engaged in educational improvement.

Also part of the Eisenhower Network are 12 ENC Demonstration Sites—one in each region, one at ENC on The Ohio State Univesity campus in Columbus, Ohio, and one at The George Washington University in Washington, D.C. These sites provide visitors with the opportunity to access ENC services electronically and to pick up free publications.

In recent years, the Eisenhower Network has spread even further with the creation of ENC Access Centers. Located throughout the country, these volunteer centers are staffed to distribute ENC publications and to teach local educators about the Eisenhower Network. There are already 125 Access Centers, with more added each month.

Pacific Region

American Samoa, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Guam, Hawaii, Republic of the Marshall Islands, Republic of Palau



Consortium

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Contact the Eisenhower Consortium or ENC Demonstration Site that serves your state for assistance in improving mathematics and science education.

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demo site

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Eisenhower National Clearinghouse for Mathematics and Science Education

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demo site

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enc
Eisenhower National Clearinghouse

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Mid-continent Region

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ENC Capital Collection & Demonstration Site

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demo site

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Appalachia Region

Kentucky, Tennessee, Virginia, West Virginia

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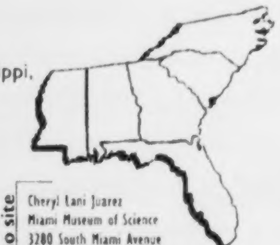
Southeast Region

Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina



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Focus on

Mathematics and Science Across the Curriculum

This section presents articles on the theme of this issue.

Themes for *ENC Focus*

Each issue of ENC Focus presents articles on a topic of concern to classroom innovators. Previous issues have covered topics such as Mathematics and Science Across the Curriculum, New Horizons in Mathematics and Science Education, Literacy in Mathematics and Science, Teaching in the Standards-Based Classroom, and Making Schools Work for Every Child. The online version of ENC Focus (enc.org/focus) provides the full text of all issues.

The best source of new ideas and helpful tips for improving science and mathematics education is the classroom teacher. We invite you to join the community of *ENC Focus* writers. Check page 5 for upcoming themes. Our guidelines for writers appear on page 10 and online (enc.org/focus/write).

Teachers Need a Special Typ

"Teachers' mathematics" and "teachers' science" are not watered-down content, but content aimed at a particular profession.

by Zalman Usiskin, University of Chicago

It is a truism: To teach content, the teacher should know that content well. For a teacher of middle school or high school mathematics, this means knowing a good deal of algebra, geometry, analysis, statistics, number theory, computer science, and mathematical modeling. For a teacher of elementary school mathematics, this means knowing numbers and operations, measurement and geometry, algebra and functions, and probability and statistics at least as well as the graduate of a solid high school program would. The teacher of science needs analogous breadth of knowledge: biology, chemistry, physics, environmental science, Earth science, and so forth.

The idea that prospective teachers should take more mathematics or science courses would not seem to have any downsides, but it can create a problem. Aside from courses designated for elementary school teachers, the courses taken by an undergraduate in a teacher preparation program are in most places virtually identical to the courses taken by a student who aspires to do research in the subject. Often, the more subject-matter courses a teacher takes, the wider the gap between the content the teacher studies and the content the teacher teaches.

The result of the mismatch is that teachers are often no better prepared in the content they will teach than they were when they were students themselves. A beginning high school mathematics teacher may know little more about logarithms, factoring trinomials, congruent triangles, or volumes of cones than is found in a high school textbook. A beginning biology teacher may know little more about human physiology than is taught in some high school biology courses.

There is a need for more content courses designed for teachers, that is, courses in what might be called "teachers' mathematics" or "teachers' science."

Such courses should include at least:

- ways of explaining and representing ideas new to students,
- alternative definitions and their consequences,
- why concepts arose and how they have changed over time,
- the wide range of applications of the mathematical ideas being taught,
- alternative ways of approaching problems with and without calculator and computer technology,
- extensions and generalizations of problems and proofs (in mathematics) and experiments (in science),
- how ideas studied in school relate to ideas students may encounter in later mathematics and science study, and
- responses to questions that learners have about what they are learning.

Some of this has been termed "pedagogical content knowledge," but it is more accurately the content knowledge needed to teach well. Teachers' mathe-

# of Content Knowledge

matics and teachers' science do not present watered-down content, but content aimed at a particular profession, just as actuarial science is aimed at present and future actuaries.

Research areas in science and mathematics tend to be narrowly focused, but the teacher needs to be widely educated. Teachers' mathematics and teachers' science range from familiarity with the latest developments in the subject to consumer uses, from the history of the subject to preparation for new careers. Teachers' mathematics and teachers' science include both standard and alternative conceptions of ideas.

Teachers' content emanates from the classroom just as statistics emanates from data. It has its own technologies that researchers in science and mathematics do not need to know. It is applied mathematics and applied science with its own special knowledge, special enough that a course in teachers' mathematics would not be particularly helpful in the teaching of science, and vice versa.

Currently, teachers' content is picked up by teachers haphazardly. Teachers may find it in occasional articles in journals, newsletters, or magazines like this one. Or they may learn it by attending conferences, by reading the teachers' notes found in textbooks, by discussing teaching with colleagues, or by examining research in history and conceptual foundations of school mathematics and science.

A recent national report supports the idea that this kind of mathematics (and, I will add, science) needs to attain a significant place in the experiences of preservice and inservice teachers (Conference Board, 2001). Under a grant from the Stuart Foundation, a group of us has created enough material for at least two upper-level college mathematics courses, and we have only touched the surface of the subject (Usiskin et al., 2003). We can expect to see a significant amount of subject-matter materials written especially for middle and high school teachers within the next few years. The problem is how to fit such courses into already crowded teacher-preparation programs.

Zalman Usiskin is professor of education and director of the University of Chicago School Mathematics Project.

References

Conference Board of the Mathematical Sciences. (2001). *The Mathematical Education of Teachers.* Providence, RI: American Mathematical Society.

Usiskin, Zalman, Peressini, Anthony L., Marchisotto, Elena & Stanley, Dick. (In press; expected 2003). *Mathematics for High School Teachers—An Advanced Perspective.* Upper Saddle River, NJ: Prentice-Hall.

Photo: Bruce Deep

ENC is hosting an online discussion of this article. Join other educators talking about questions such as these:

DISCUSS

Do you agree with Usiskin? What examples can you cite from your experience?

If you could help design a teachers' mathematics course or a teachers' science course, what topics would you include?

Do you think teachers' mathematics or teachers' science courses would eventually lead to increased learning for K-12 students?

Visit enc.org/focus/content/discuss

An Interview with Liping Ma

“Do not forget yourself

With her book, *Knowing and Teaching Elementary Mathematics*, Liping Ma caused many to question the depth of teachers’ understanding of the subject. For more about Liping Ma, see the related article below.

by Terese Herrera, ENC Instructional Resources

Liping, through your book we glimpse a much deeper, coherent picture of arithmetic. Our students need that. Our teachers, I believe, are hungry for it. How do we achieve it?

I don’t know. I really don’t know. I think that many should work on this.

First, mathematicians who teach content courses in universities should think about arithmetic in a deeper way. In earlier centuries, great mathematicians devoted their whole lives to solving complex problems through applied arithmetic. Today’s mathematicians are working on advanced branches of mathematics, but for those who teach core content for future elementary math teachers, knowledge of advanced mathematics is not enough.

In China, deep arithmetic knowledge is not owned by the mathematicians. It is owned by teachers at the elementary school level. It is not in a book; it is in their minds, and they pass the knowledge on to the next generation. Here in the United States, I personally don’t see this body of knowledge in teachers’ minds. I don’t know why. I hope someone can research and document American teachers’ knowledge of arithmetic. This would be very helpful for our teachers.

Math educators need to think not only about how teachers will teach math but also about the math they are going to teach. In the United States, one group of professors teaches content; another group teaches method. But teachers realize that we cannot separate content from method—what to teach from how to teach. In a teacher’s real life, they are combined.

We [teacher educators] have no way to put that deep knowledge of elementary math in teachers’ minds either. We don’t have an answer to give to them. Teachers should know that this is not something that they should wait for other people to give them because we don’t have it. We should tell them that it is not their fault at all, and we should encourage them to deepen their knowledge of elementary math through their own teaching.

Teachers themselves should ask “Why?” all the time. When they teach multiplication to their students, they can think about why it works. Then they will learn elementary math in a deeper way through their own teaching of it.

continued on page 18

A Deeper Look at Elementary Mathematics

How did Liping Ma, author of *Knowing and Teaching Elementary Mathematics,* develop her insights into the importance of content knowledge for elementary teachers?

by Melanie Shreffler, ENC Publishing

Liping Ma has had very little formal math training. During China’s Cultural Revolution, one month before she was to have finished the eighth grade, she was forced to leave Shanghai and sent to a countryside village to be “re-educated” by the peasants. Instead, the peasants asked her to teach them to read. She spent the next several years in the small rural community running its elementary school.

As the Cultural Revolution ended, Ma wanted to attend a university, but China had an age limit for admittance into an undergraduate program. At 23, Ma was too old. She was interested in studying education—her years teaching in the small village had piqued her curiosity. She passed an entrance exam to be admitted as a student in a master’s degree program.

Following the completion of her master’s degree, the government assigned her a job. But the government doesn’t always assign people to jobs they want. Ma was placed at a research institution for higher education in Shanghai. Still dedicated to elementary education, Ma applied to go abroad to study at Michigan State University.

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as a teacher of yourself”

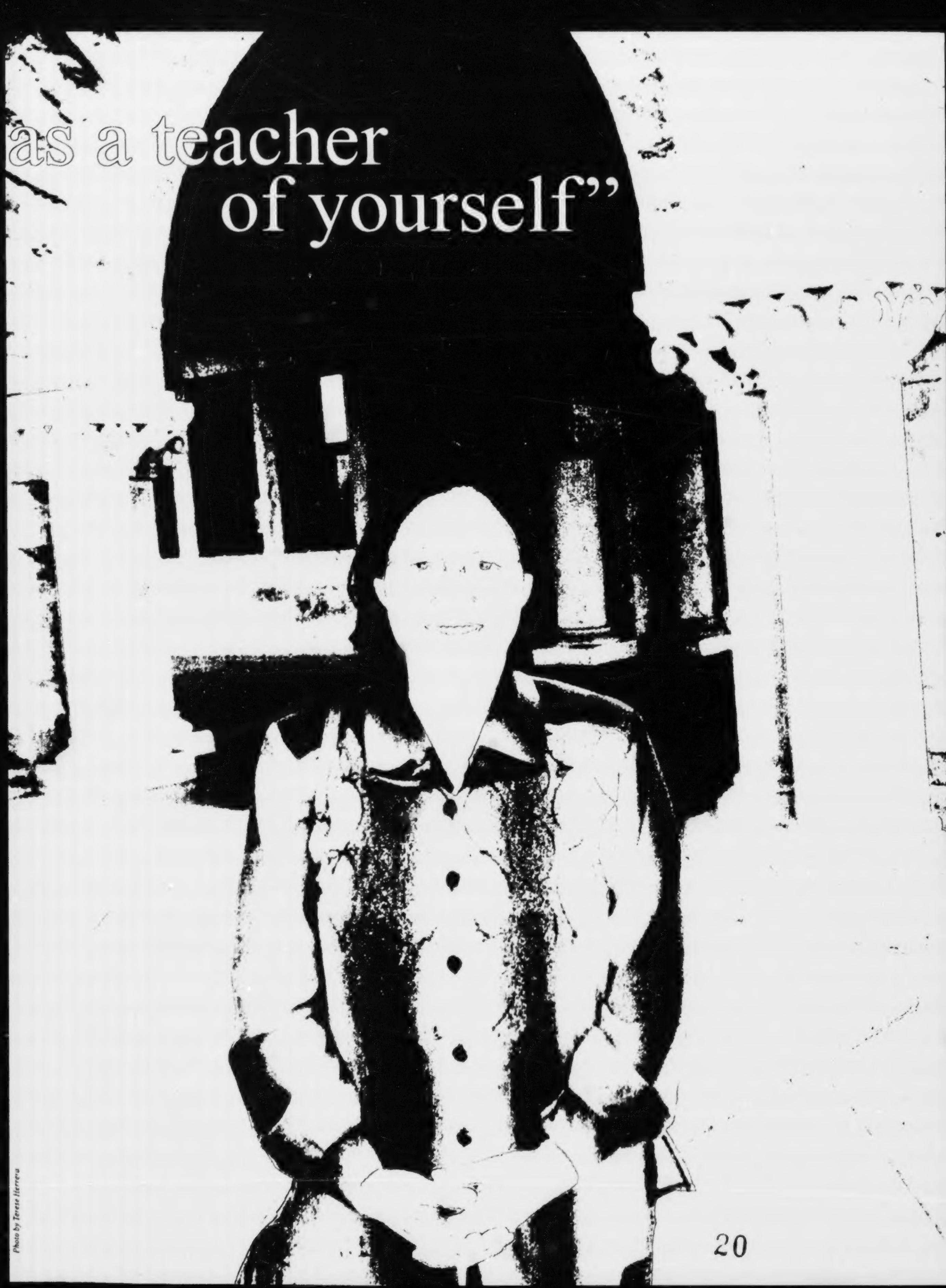

Photo by Terese Herrera

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Again, I don't think that I have the answer. I am in the process of looking for answers. There will not be an easy answer for what we should do or a quick solution. We should work together—and work hard—mathematicians, math educators, and teachers.

Your book focuses on arithmetic. How do you see the teaching of geometry in the early grades?

Again, for me it is still a question. At the K-6 stage I see arithmetic as the main focus of elementary math, even though elementary geometry should be included.

The geometry that we are teaching now in this country at the elementary level does not connect tightly enough with arithmetic. We teach children the names of shapes—rectangles, triangles, and so on—but not the connection between those shapes. Two congruent triangles can make a rectangle, for example; this is a connection between those figures.

And we need to teach the connection between the geometric figures and other mathematics. For example, we talk about the perimeter of a rectangle as equal to length + length + width + width. The perimeter also equals (length + width) × 2.

Children could discuss why the formula can be written both ways and which way it makes more sense, is more clear, more mathematically advanced. Doing so, they connect this geometry piece to arithmetic and with the way they think mathematically.

Is there a role for calculators in elementary math classes?

I've had a question in mind for a long time: Since there are calculators that can solve all the skill problems in arithmetic, why do we teach children arithmetic? It is very important to ask this question. It challenges us to sit down and think carefully about what we really want our children to learn.

I believe that arithmetic is much more than skills; it is a basic tool to develop children's minds, their way of thinking. The question becomes: What role does arithmetic play in the development of a child? It is just like asking: What role does literacy/reading play in the development of a child?

I am always asked about calculators in the classroom: Should they be allowed? This is not the question. Calculators are already in use. What we need to consider is how they should be used. In what way can calculators help students learn more mathematics and learn it in a better way?

Your book has influenced the math education community at many levels. What are you working on now?

I am a visiting scholar at the Carnegie Foundation because I have a post-doctoral grant for research. My research is on what I call the cornerstone ideas of elementary math. I often hear the terms "core ideas," "big ideas," "important ideas," meaning those ideas that hold all the pieces of a subject. However, it seems that no one is doing systematic research on what these ideas are, why they are central, and how they contribute to the learning of elementary math.

I began last year with pilot studies in kindergarten classes. I developed some teaching materials, including multimedia math games. All of these games are designed for teaching math ideas. My questions are: How do these games work with children? How do students learn? How can teachers learn through teaching?

I go into the classroom to observe the instruction and note what is wrong with my idea. I don't send in others to collect the data. I use myself as the instrument of thinking, because of my early experience in teaching math and observing others teach, and because of my focus on how to create good math teachers. All of those experiences form my vision and make me, myself, an instrument to collect and analyze data. It is a very personal and interior kind of research.

If grants become available, I want to study math textbooks to determine their central ideas and work further with more teachers. The ideas proposed as central to elementary mathematics should then be tested in classrooms, K through 6. We need to lay out the arguments for why certain ideas are central in terms of the subject and in terms of children's learning, and how these ideas can be taught.

I understand you've also written an intervention program for intermediate grades?

Houghton-Mifflin wanted to develop a program for children in grades four and up who are below their grade level in math. Cathy Kessel, a fellow researcher who did the heavy editing on my book, and I wrote a student book and teacher's manual. The series is called the Knowing Mathematics Transition Program. Our goal was to create a 12- to 14-week intervention that would bring the students up to their grade level.

Many teachers mentioned that these students don't know the basic facts, multiplication tables being their most obvious trouble. Some teachers let the students use calculators, but using calculators alone is not good. Children need to know multiplication tables on their own. They can push buttons and find the numbers, but they don't know the meaning of the numbers. They might not even know that 35 is two more than 33. Numbers make no sense to them, so we decided to help them to overcome this problem of not knowing basic facts.

We concentrated on the real math behind facts and then the facts themselves. We use a question as the title for each daily lesson: "What is a number?" or "Can you turn addition into subtraction?" or "Do you know the trick for computing with 9?"

Each lesson includes two parts–math conversation between the teacher and a group of students, presented as a small play, and a set of math problems. For the lesson on adding with 9, for example, we show this pattern and ask the students to fill in the blanks.

9 + 1 = 10
9 + 2 = 11
9 + 3 = 12
9 + 4 = 13
9 + 5 = 14
9 + 6 = ___
9 + 7 = ___
9 + 8 = ___
9 + 9 = ___

After a few more patterns, we ask them the trick for computing with 9 and why it works. Mainly this lesson is for reflection on the concept. The numbers are very simple, but we want the students to play out the ideas. We think that the easier the numbers are, the easier it is for the students to think about the concept behind them.

For every two-page lesson, one page is a set of problems; children need practice and each problem is closely linked to the day's concept, or to concepts and skills learned in earlier lessons.

The teacher's manual models the classroom discussion for students and teachers, giving teachers questions to ask and explaining why the questions are included. In field tests, both students and teachers enjoyed the discussions. An example of a concept for discussion is the real meaning of subtraction. We usually talk only about "take away," but then why do people call the result of subtraction "difference?" In one lesson we discuss how "difference" is the one concept underlying different models of subtraction. They come to realize that this meaning is much more powerful than "What is left?"

I learned a lot of elementary math through designing this program, through asking myself "Why." Why are addition and subtraction facts so difficult to learn? One consideration is the number of these basic facts: 81 for addition and 81 for subtraction.

The 81 Addition Pairs

1+1=	1+2=	1+3=	1+4=	1+5=	1+6=	1+7=	1+8=	1+9=
2+1=	2+2=	2+3=	2+4=	2+5=	2+6=	2+7=	2+8=	2+9=
3+1=	3+2=	3+3=	3+4=	3+5=	3+6=	3+7=	3+8=	3+9=
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8+1=	8+2=	8+3=	8+4=	8+5=	8+6=	8+7=	8+8=	8+9=
9+1=	9+2=	9+3=	9+4=	9+5=	9+6=	9+7=	9+8=	9+9=

What is the real idea behind these pairs? In this table, 20 pairs of numbers have sums less than 10, and most intermediate grade students feel comfortable with these addition facts. There are five pairs that have a sum of 10:

9,1; 8,2; 7,3; 6,4; 5,5

Then there are another 20 pairs with sums beyond 10:

9,2; 9,3; 9,4; 9,5; 9,6; 9,7; 9,8; 9,9

8,3; 8,4; 8,5; 8,6; 8,7; 8,8;

7,4; 7,5; 7,6; 7,7;

6,5; 6,6

Actually, most fourth graders who are behind in addition and subtraction are behind only because they are not good at these 20 pairs.

Now we can concentrate on those pairs, including the eight pairs related to the number 9, which explains why we included the lesson on finding a trick to compute with 9. When students have learned the trick and practiced it, they have learned those eight pairs and can move on to the doubles. They reduce those doubles little by little, ending up with less than ten pairs that have to be learned by rote. Through this approach we teach students basic facts while they learn more about numbers. They cannot learn this by punching the buttons on calculators.

When teachers use this kind of book, where they have to teach math in a different way, we hope they will learn more math naturally through teaching it. They will also learn more about what makes elementary math challenging for students.

What would you say to elementary teachers who want to improve their mathematical knowledge and their teaching?

If I were a teacher, I would be very aware that there is no existing body of knowledge that I could study chapter by chapter. If I want to improve myself, I must first depend on myself. I would ask myself "Why?" all the time as I teach elementary math. I would also discuss math teaching and learning with other teachers in my school who teach at the same grade level. Conversation stimulates our thinking.

A layperson only needs to know how to do math, but a teacher needs to learn more because his or her students need a whole picture—a whole concept. Students develop the power of their minds through learning conceptually. Mathematicians may not need these conceptual tools because they have them internalized, but students need tools to develop their abstractive way of thinking.

Teachers who feel that they need more content math knowledge should depend on themselves, never forgetting that they are their own teachers. Their own classroom teaching is the main process through which they can learn. That really makes sense to me.

Could I ask you for any final thoughts?

Society is telling teachers so many things, and everybody who tells them something seems to have authority—psychologists, researchers. Today's workshop says this is good, and tomorrow's workshop tells them something else. Who is the teacher to believe?

Teachers should have confidence in themselves. They are the ones who digest all the knowledge, who listen and change it into a "whole" through their own understanding. I don't know if the word *soul* is the right word here, but I think teachers are the soul that gives out the light of all the knowledge they hold. I really want them, and us as math educators, to think about that. Otherwise, teachers feel that everybody knows more than they do. Then they lose themselves. I would tell teachers: "Do not forget yourself as a teacher of yourself."

Terese Herrera is the mathematics resource specialist at ENC. Her career includes 15 years of teaching mathematics at the middle school and high school levels. Email: therrera@enc.org

Reference

Ma, Liping & Kessel, Cathy. (2001). Knowing Mathematics Series. Boston: Houghton Mifflin.

DISCUSS

ENC is hosting an online discussion of this article. Join other educators talking about questions such as these:

How can you use Liping Ma's ideas in your teaching? Can you describe a situation in which you used your own class room teaching as a process to help you learn?

Visit enc.org/focus/content/discuss

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Coming to America

When Ma received her acceptance letter from Michigan State, she was able to understand most of what it said. (She had taught herself English so that she could read "education classics.") When she arrived in Michigan, she had $30 in her pocket because that was all that the government would allow her to exchange before leaving China. So, Ma found an assistantship working with a project focusing on teachers' math content knowledge.

Deborah Ball, then a professor and researcher at Michigan State, had designed four interview instruments for the project to gauge teachers' content knowledge. The instruments probed teachers' understanding of subtraction with regrouping, multidigit multiplication in which the student had made a mistake, division by fractions, and acceptance of a student theory about the relationship between area and perimeter of rectangles. Ma's job was to code data from transcripts that Ball and others collected.

As she worked, Ma noticed that only one teacher could construct a story that accurately matched the division by fractions problem. Thinking about how she was taught and how she had taught her students, Ma realized that Chinese teachers would give different answers to the four problems. With a grant of $1,000, she returned to China to conduct a pilot study of ten teachers to see how they would respond to one of the instrument questions. Her hypothesis proved true; the teachers offered different answers, just as she had suspected.

Returning to the United States and transferring to Stanford University to pursue her doctorate, Ma built on her pilot research for her dissertation, which then evolved into her book, *Knowing and Teaching Elementary Mathematics.*

Cross-Cultural Mathematics

In 1998, at the time of her dissertation research, several reasons were being offered for why Chinese students did better in mathematics than American students. Ma focused her research on finding out if teachers' content knowledge makes a difference, and, if it does, what knowledge Chinese teachers have that American teachers are lacking.

Using the research questions Ball had designed, Ma interviewed 72 teachers in China, making sure that she included some of the best teachers. She compared her data with the data from the Michigan State study using a sample of 23 teachers who were participating in an intensive professional development project. Of those 23, some were new teachers who had taught for one year, and some were experienced teachers.

In part of the research Ma discusses in her book, teachers were asked how they would correct student errors in multiple-digit multiplication such as this:

$$\begin{array}{r} 123 \\ \times 645 \\ \hline 615 \\ 492 \\ 738 \\ \hline 1845 \end{array}$$

American teachers suggested several solutions to correct the student's mistake. They mentioned using graph paper to help students line up their numbers properly; they suggested using a placeholder. Several recommended zero as a place holder, but a few suggested instead a smile face or an asterisk because zero might confuse their students by making them think the number changed by adding a zero. Some American teachers suggested helping the student by breaking it into three problems: 123 × 600, 123 × 40, and 123 × 5. The teachers mentioned several processes, but rarely the mathematical reasoning behind them.

Chinese teachers offered several mathematical solutions to help the students, but they also continually told Ma that this was the wrong question to ask. They thought Ma should have asked them about multiplication of two digits by two digits. If their students would make a mistake lining up products, it would be then. The Chinese teachers insisted that by the time their students get to three-digit multiplication, they almost never make such mistakes.

The Chinese teachers explained that they prepare students for more complex ideas early on. During one-digit multiplication, they emphasize that all numbers in the problem and the product have place values.

In learning two-digit multiplication, students are introduced to a new mathematical concept and a new computational skill. Chinese teachers take their time teaching two-digit multiplication; they consider it to be the key to all multidigit multiplication. During their instruction the teachers continue to stress place value by asking the students, "Why do you need to move [the partial product] over?"

By the time the students get to three-digit multiplication, they understand the process and skills to solve the problem, and the teachers don't need to teach the step-by-step procedure. Instead, they often have students try to figure it out on their own. Because they have been thoroughly prepared, most students can solve the problems without trouble.

The Role of Content Knowledge

Ma had asked if teachers' grasp of mathematics affected their teaching ability. In her book, she summarizes her observations saying, "Not a single teacher was observed who would promote learning beyond his or her own mathematical knowledge" (p. 54). Her study of content knowledge has revealed that "a teacher's subject matter knowledge may not automatically produce promising teaching methods or new teaching conceptions. But without solid support from subject matter knowledge, promising methods or new teaching conceptions cannot be successfully realized" (p. 38).

Ma made an important observation as she evaluated the question of multidigit multiplication. When teachers described how they would correct their students' mistakes, their suggestions were limited by their content knowledge. Teachers with only procedural understanding of the problem could not give conceptual help to their students.

For example, almost all of the teachers in the study mentioned place value as necessary knowledge for students to correctly complete the multidigit multiplication problem. The difference came in their explanations. Teachers with procedural understanding used place values merely as names for the columns in the problem. For example, one American teacher said, "I would go back to place value and tell them that when they are multiplying by the ones, it is lined up with the numbers above. And that when they moved to the next number, which is the tens, it lines up with the tens" (p. 34).

Teachers with conceptual understanding referred to the place value of each number in the problem. Referring to the student error on this page, one Chinese teacher said, "When [students] saw a number 492, it always meant 492 ones. But now the place value of the basic unit is no longer a unique one. It changes according to the context. For example, the place value of the 4 in the multiplier [645] is ten. When we multiply 123 by the 4, we regard it as 4 tens. Then tens becomes the place value of the basic unit of the product

492. It is not 492 ones, like it is in the student's work, but 492 tens" (p. 43).

Some teachers with conceptual knowledge chose instead to remind their students of the distributive law, as explained by one Chinese teacher (p. 40):

> First, I will put on the board an equation and work through it with students:

$$\begin{aligned}123 \times 645 &= 123 \times (600 + 40 + 5)\\ &= 123 \times 600 + 123 \times 40 + 123 \times 5\\ &= 73800 + 4920 + 615\\ &= 79335\end{aligned}$$

> What allowed us to transform the problem? The distributive law. Then I will suggest the class rewrite the equation into columns:

$$\begin{array}{r} 123\\ \times 645\\ \hline 615\\ 4920\\ \underline{73800}\\ 79335\end{array}$$

> I will ask students to observe the zeros in the equation as well as those in the columns. Do they affect the sum? Why yes, and why no? After a discussion [about zeros] I believe the lining-up way in multiplication will make sense to the students.

Some teachers with conceptual knowledge referred to both distributive law and place value to be certain to clarify the student error. This is the kind of deep thinking that Ma believes teachers need to be able to help their students truly understand mathematics.

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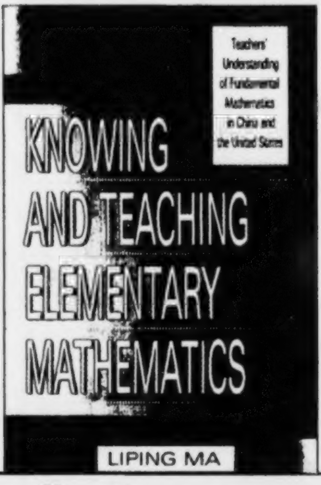
Teachers' Understanding of Fundamental Mathematics in China and the United States
KNOWING AND TEACHING ELEMENTARY MATHEMATICS
LIPING MA

For a description of Liping Ma's book *Knowing and Teaching Elementary Mathematics*, see the Focus on the Collection section of this magazine, page 68.

Staying a Step Ahead

If you allow students to follow their own inquiries, you will be challenged to upgrade your content knowledge every step of the way.

by Pamela Galus, Burke High School, Omaha, Nebraska

> *Science is built of facts the way a house is built of bricks, but an accumulation of facts is no more science than a pile of bricks is a house.*
>
> —Henri Poinca, theoretical scientist (1854-1912)

As a traditional teacher for most of my teaching history, I had given many students a pile of bricks, but few of the students had shown any inclination to do anything with the bricks once their multiple-choice tests were complete. If the learner is not interested, the quality of the information being presented makes little difference. I began to search for ways to engage the high school students in my Earth science classes in their own learning.

I signed up for a staff development offering called Career Connection to Teaching with Technology. Funded by a Technology Innovation Challenge Grant from the U.S. Department of Education, the offering was designed to develop technology-based units for all subject areas. I and other participants were required to write four units during the year.

According to the plan, we would identify and address national standards in our units as well as incorporate technology. Eventually the units would be posted at the Apple Learning Interchange web site (www.ali.apple.com/egli), where teachers nationwide would be able to read them. The units would be peer reviewed and peer field tested before they were posted.

The staff development program provided a subject specialist to help guide teachers in the construction of the curriculum and to clarify concepts as teachers moved out of their comfort zone into topic areas that they were less familiar with. I could call the specialist when questions arose that I was unable to answer. In some instances, the specialist provided web sites, literature resources, or methods that students might use to search the Internet.

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23 pairs of legs
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n known to jump
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fruit fly is 12-46 days.
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Photo by Pamela Galus

Putting My Learning in Action

Before beginning each unit, I asked the class a number of questions to find out what students already knew about the topic and where their interests lay. For example, when we began a unit on environmental issues involved in the disposal of waste products, I asked the students to think about the conditions necessary to cause substances to decay. The students themselves began discussing such terms as *biodegradable* and *nonbiodegradable*, *organic* and *inorganic*. My role became one of a coach; my goal was to keep the players interacting as a team so that I could learn more about their prior knowledge, misconceptions, and interests.

The students did not reach a consensus about decay during the first day of the unit, so I challenged them, and myself, to discover what we wanted to know. We used various resources to learn more about landfills.

From their research, the students learned that trash disposal techniques have undergone a great many changes during the course of human history. We learned that allowing water to run through the landfill can be an environmental threat because the water can pick up toxic materials and wash them into drinking water. Modern landfills are capped off with a layer of material of low permeability to prevent water from moving through the debris placed in a lined landfill. In our discussions, most of the students had agreed that water was one of the variables necessary for decomposition. The questions then became: Does the layer that caps the landfill, combined with the clay layer around the debris, prevent both water and air flow? Is air necessary for decomposition?

Allowing students' interest to guide a classroom unit can create some challenges. Through their research, students found a great deal of information, and they quickly surpassed my own understanding of the topic. To teach this lesson, I needed an in-depth understanding of the history of garbage disposal as well as current disposal technologies. I had to understand the variables that students would need to consider, how they interrelate, and how an in-class experiment would limit the validity of any experimental design. I had to have access to information about water purification. Of course, I also had to know a great deal about geochemical cycles.

Before and after school, I found myself on the Internet researching topics before they arose in the classroom. I made printouts and books available to the students. Staying one step ahead of young people who are enthusiastic about a subject is time consuming and challenging.

I discovered one gambit that saved time and was beneficial to me and the students. When students asked questions that I could not answer, I offered the class extra credit if they found the answer in a reliable source. (Earlier in the year, the students had learned how to identify Internet sources by their domain names and other clues.) Working together in this way improved the quality of the information for everyone.

The students' questions about decomposition resulted in an experiment with nine landfill models created in plastic shoeboxes in the classroom. When students were allowed to ask their own questions and search for the solutions, their interest and learning increased—and so did mine!

Pamela Galus is an Earth science teacher at Burke High School in Omaha, Nebraska. She has published articles in Educational Leadership, The Science Teacher, Instructor, NEA Today, *and* Science Scope. *Her article "Writing for Professional Journals" appeared in the January 2002 issue of* ENC Focus. *Her email address is pgalus@ops.org*

DISCUSS

ENC is hosting an online discussion of this article. Join other educators talking about questions such as these:

Have you ever let students take the lead in this way? What happened?

Visit enc.org/focus/content/discuss

ENC Can Help You Increase Your Content Knowledge

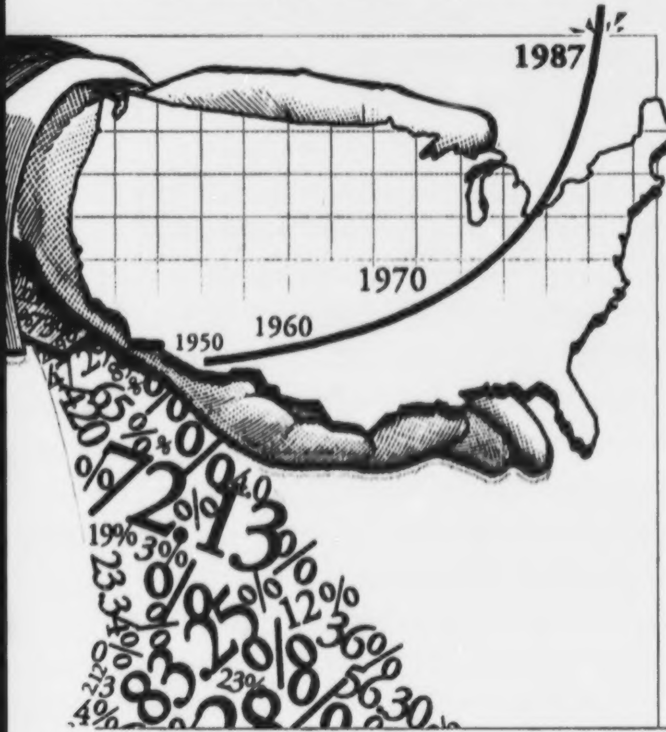
ENC's Classroom Calendar mathematics and science information on topics of interest to you.

by Judy Spicer, ENC Instructional Resources, and Laura K. Brendon, ENC Information Services

ENC's online feature Classroom Calendar (enc.org/thisweek/calendar) is a great resource to help you increase your mathematics and science knowledge. Although Classroom Calendar is organized by month, entries can be accessed by category also.

Each Classroom Calendar entry features material that can refresh or expand your math or science knowledge related to the topic. Entries include information in several categories such as Connections, Web Resources, and Ready-to-Go Activities. The Connections section suggests ways to add content and enrich topics within and across subjects areas.

If your goal is to increase your content knowledge, you will want to explore the list of Web Resources with each entry. These web sites have been carefully selected to offer accurate, up-to-date math and science information. The Ready-to-Go Activities feature links to classroom activities for use on and off line. Also found with most entries are a list of related resources found in the ENC collection and correlations to national math and science standards.



ENC graphic: Andy Ault

Statistics of the Descriptive Variety

(Classroom Calendar Entry for August 2)

by Judy Spicer

There are three types of lies: lies, damn lies, and statistics.
—Benjamin Disraeli (1804-81)

As you can tell from the above quote attributed to 19th-century British Prime Minister Benjamin Disraeli, interest in, and suspicion of, statistics is not new. Today we are bombarded with statistics from many sources. A basic understanding of statistics is crucial to understanding and evaluating public and personal issues—from environmental and health risks to financial investments.

Here is an example of how the easy acceptance of a misquoted statistic can lead to a surprising conclusion. Joel Best in his book *Damn Lies and Statistics* (2001) labels the statement: "Every year since 1950, the number of American children gunned down has doubled" as the worst—that is, the most inaccurate—social statistic ever written. In the book, Best traces the implications for the doubling statistic: "If the number doubled each year, there must have been two children gunned down in 1951, four in 1952, eight in 1953, and so on.... In 1983, the number of American children gunned down would have been 8.6 billion (about twice the Earth's population at the time)." Best further notes that according to this doubling process, the number of children shot in the United States in 1987 would have amounted to about 137 billion. That number is greater than the estimated grand total of the world's population from the time of the first humans—about 110 billion.

The source of this inaccurate statement found in a doctoral dissertation was a journal article. When questioned, the article's author cited *The State of America's Children Yearbook—1994*, a report from the Children's Defense Fund. Best discovered that the yearbook does state: 'The number of American children killed each year by guns has doubled since 1950." By rewording that claim, the article's author created a very different meaning.

This example should remind us that just because a statistic is in print or on the web does not mean it is true. Any statistic may be accidentally, or purposefully, misleading, inaccurate, or simply misinterpreted. We need to think critically about the implications of statistical information and be willing to do some calculating to check for accuracy. Being familiar with elementary statistics and fundamental mathematics topics such as exponential growth is crucial for understanding and being informed.

Connections

Instructional programs from prekindergarten through grade 12 should enable all students to formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them (NCTM, 2000).

The 2000 NCTM standards, *The Principles and Standards for School Mathematics*, and state curricula contain strands supporting the teaching and learning of data analysis and statistics. This Classroom Calendar entry features web sites with background information about descriptive statistics for the teacher. The suggested sites make use of the web's possibilities for interactively exploring statistics topics. Featured explorations include graphing data and examining the differences among the three common measures of central tendency: mean, median, and mode. You will also find examples and applications for investigating the more advanced statistic topics of variance, standard deviation, and linear regression.

At many of the featured sites, interactive models allow you to experiment with the data and instantly see, on related graphs, the effects of changing one or more pieces of data. Ready-to-Go Activities contain lesson ideas for introducing students to the use of statistics in real-world situations and suggest sources for real-world data. When teaching statistics, get ready to use educational technology—graphing calculators, spreadsheets, and computers—to analyze data.

You'll also find opportunities for studying statistics as part of cross-curricula units, such as historic or current U. S. Census data in social studies units.

JUMP ONLINE

Visit Statistics of the Descriptive Variety online (enc.org/thisweek/calendar) for an extensive list of and direct links to related web resources and materials selected from the ENC Collection.

Judy Spicer is senior mathematics abstractor at ENC. Email: jspicer@enc.org

References

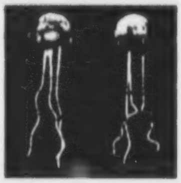
Best, Joel. (2001). *Damned Lies and Statistics*. San Francisco: University of California Press. Retrieved March 7, 2002: www.ucpress.edu/books/pages/9358/9358.intro.html

National Council of Teachers of Mathematics (2000). *Principles and Standards for School Mathematics*. Reston, VA: Author.

Neon Lights

(Classroom Calendar Entry for December 11)

by Laura K. Brendon



On this date in 1910, neon lights made their public debut, casting a rosy glow at the Paris (France) Auto Convention. Besides dazzling red, neon lights come in luminous orange, hot pink, tropical green, and, in fact, just about any other color. The lights can be formed into all kinds of shapes, from palm trees to pelicans. And they make everyday words such as *restaurant* and *ice cream* positively shine. Sixty years ago, almost every store had a neon sign in its window, and recently neon lights have made a comeback as an art form.

It's fitting that neon lights were first introduced in Paris since the man who invented them was the French scientist Georges Claude. (He did not discover the element neon. Great Britain's William Ramsey and M. W. Travers discovered it in 1898.) Claude studied, among other elements, the inert (or noble) gases—helium, neon, argon, krypton, xenon, and radon. Although these gases are colorless under normal conditions, they glow if an electrical charge is passed through them. By chance, Claude created the neon light when, as part of his experiments, he sent electricity through a sealed glass tube that contained neon. Voila! The tube glowed red and the neon light was born. He continued to experiment with other gases and added other colors.

An associate helped Claude recognize the possibility of using the gas-filled tubes to make attractive signs. Even more important for the commercial success of neon lighting, Claude developed reliable, compact, noncorroding electrodes.

The glass tubes that hold the neon gas come in various lengths and diameters. Each tube is scored and cut to length. An artist or other glass worker heats the glass and bends it to form the desired shape. Electrodes are fused to both ends of the tube. Most of the air is pumped out through a vent. The remaining air is superheated to cook impurities out of the glass. As the glass cools, the rest of the air and impurities are pumped out with a vacuum pump, the neon or other inert gas is pumped in, and the tube is sealed.

Power is supplied to the electrodes through a transformer. When that happens, the gas inside the tube ionizes, which produces the neon lights' distinctive and uniform glow. While neon is often used to fill the tube, other inert gases can also be used. It depends on the color needed. Each gas glows a different color. For example, argon glows lavender, and argon combined with mercury glows blue. The tubes are coated with phosphors to produce various shades of other colors.

You might notice that many neon signs are in script. The most efficient design for signs is to use tubes that are continuous, so that each section of tubes does not have to be plugged in separately. Manufacturers apply a black coating to parts of the tube to indicate spaces between letters or words.

Unlike incandescent or fluorescent bulbs, neon lights last for years, are resilient, and do not need fixtures for support. By combining different gases and phosphors, around 150 colors can be produced in clear glass tubes. Tubes may now be colored, an innovation that means an even wider range of colors can be obtained.

Laura K. Brendon is the coordinator of Information Services at ENC. Email: lbrendon@enc.org

References

Encyclopaedia Britannica. Claude, Georges. Accessed August 23, 2000: www.britannica.com/eb/article?eu=24619&tocid=0&query=claude%2C%20georges

Encyclopaedia Britannica. Noble Gas. Accessed August 23, 2000: www.britannica.com/eb/article?eu=119791&tocid=81100&query=noble%20gases

Perszyk, Peter. (2001). Neon: The First Hundred Years. *Lighting Design + Application*, 31(7), 52-56.

Stern, Rudi. (1979). *Let There Be Neon*. New York: Abrams.

Web, Michael. (1986). *The Magic of Neon*. Updated version. Layton, Utah: Gibbs M. Smith.

JUMP ONLINE!

Visit Neon Lights online (enc.org/thisweek/calendar) for an extensive list of and direct links to related web resources and materials selected from the ENC Collection.

Basic Skills and Conceptual Understanding: It's Not Either/Or

Leading students through balanced mathematics problems helps teachers build their own understanding of important concepts.

by Joan M. Kenney, Harvard Graduate School of Education

To one degree or another, "math wars" are being waged in every state. High-stakes testing, accountability, revised state mathematics standards, and new math curricula have unleashed a barrage of finger pointing, doom prophesying, and general bad feeling between the "traditionalists" and the "conceptualists." Proponents on both sides insist that mathematics education, particularly at the elementary level, must choose to be identified with either teaching basic skills or teaching for conceptual understanding.

Caught in the middle of this upheaval are teachers. Since many of them were educated in the traditional school of mathematics themselves, they may need help in finding a balance—and truly understanding the important mathematics concepts that give meaning to the number crunching.

To create a dichotomy between teaching basic skills *or* teaching for conceptual understanding makes as little sense as insisting that students be taught either phonics and spelling *or* expository writing and literature; musical scales *or* Beethoven's *Violin Concerto in D*; fundamentals of drawing *or* portrait painting. But in mathematics, more than other human endeavors, people tend to cling tenaciously to the idea that mastery of the basic skills, i.e., arithmetic manipulation, is the ultimate goal. Indeed, a university chancellor was quoted as saying that "for everyone except professional mathematicians, the point of learning mathematics is to be able to compute accurately" (*Boston Herald*, 2001).

Problems That Do Both

In an attempt to break down this division between basic skills and conceptual understanding, the Balanced Assessment Program at the Harvard Graduate School of

Figure 1.

Fractured Subtraction

Below is a subtraction problem that was partially erased.

$$\begin{array}{r} 8\_ \\ -\ \_7 \\ \hline 5\_ \end{array}$$

1. Can you fill in a possible set of missing digits? (The missing digits need not be the same as one another.)
2. How many possible answers are there? What are they?
3. How do you know you found all the possible answers?

Education has been designing exercises that require students not only to accurately perform arithmetic computations but also to formulate, generalize, and communicate their solutions (Schwartz et al., 2000). Figure 1 is an example of such a task.

Certainly, the task in Figure 1 requires the ability to subtract numbers, but this is only the beginning. At a more important level, this problem requires the ability to have number sense, to work within given constraints, to generalize to a conclusion, and to clearly communicate the reasoning behind the mathematical actions involved.

We have found that it is also possible to design a set of "cluster" tasks, instructional or assessment tasks that develop an important mathematical idea across grade levels. The tasks build on each other in a developmentally appropriate way so that students digest the basic arithmetic while also absorbing concepts that can be carried over to more complex problems in other settings.

Think about the concept of inverse operations. Figure 2 uses the scenario of a number ring in an example that is appropriate for primary grades; Figure 3 provides an example for the elementary grades; Figure 4 is a related task for upper elementary/early middle school.

Of course, the tasks in Figures 2, 3, and 4 require basic arithmetic facility. But, more significantly, these tasks, scaffolded as they are in a developmentally appropriate way, take students on a significant journey from math facts to math concepts.

Such tasks also provide an avenue for teachers to deepen their own conceptual understanding. As teachers lead students through the exploration of these problems, and see how the "big ideas" build from one grade level to another, they cannot help but be enriched in their own mathematical understanding and in their ability to be

DISCUSS

ENC is hosting an online discussion of this article. Join other educators talking about questions such as these:

How do you make math relevant to your students' daily lives? How do you demonstrate that they will need math in their future careers?

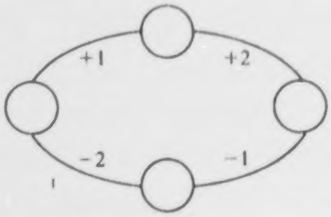
Please share a favorite problem that helps students learn basic mathematics skills while building conceptual understanding.

Visit enc.org/focus/content/discuss

Figure 2.

Add-Rings (for primary grades)

Here is a special kind of number ring. Any number that goes into one of the circles on the ring gets changed around as it goes through the other circles.

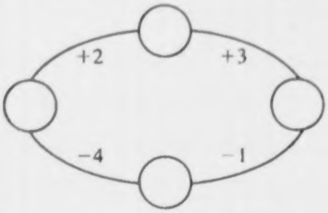


1. Try this ring. Write the number 2 inside the top circle and go around the ring. Follow the instructions to add or subtract, and write the correct answer inside each circle. What is your answer when you get back to the top circle?
2. Do this again; put the number 2 into the top circle, but this time go in the opposite direction around the ring. What is your answer when you get back to the top circle?
3. Try the ring again. This time put the number 3 in the bottom circle. Go around the ring, following the directions for addition and subtraction, and write the correct answer inside each circle. What is your answer when you get back to the bottom circle?
4. Now pick any number you wish, and put it in either one of the side circles. Follow around the ring in whichever direction you choose, adding and subtracting as you go. What happens when you get back to the circle where you started?

Figure 3.

Add-Rings (for elementary grades)

Here is a special kind of number ring. Any number you put into one of the circles gets changed as it goes around the ring.



1. Try this ring. Put a number into the top circle and follow around the ring, adding and subtracting as you go. Write your final answer above the number you started with. Describe in words what happened.
2. Try this again with another number. What is the result?
3. Try the ring again, but this time put a number into the bottom circle and follow around the ring. What is the result when you get back to your starting point?
4. Explain in words why you think you got these results.
5. Design your own number ring, using different numbers and different addition and subtraction instructions. Make sure that your ring works out the same way as the original did.

creative practitioners and facilitators in the mathematics classroom.

Mathematics for the Future

Many people feel that there is something to be said for the way their parents and grandparents learned mathematics. After all, previous generations were able to conduct business as usual, balancing checkbooks and managing household accounts. But today's students need more than basic computational skills.

The mathematics required to be successful in the culture of the early 1900s, when only about 10 percent of the population went beyond the eighth grade in school and 35 percent were involved in agriculture as their primary occupation, is equivalent to the mathematics we today expect a fourth grader to manage with facility. Unlike our agrarian forebears, who relied heavily on basic arithmetic, workers today need a firm understanding of math concepts that will allow them to make leaps from checkbook balancing to managing spreadsheets and programming computers.

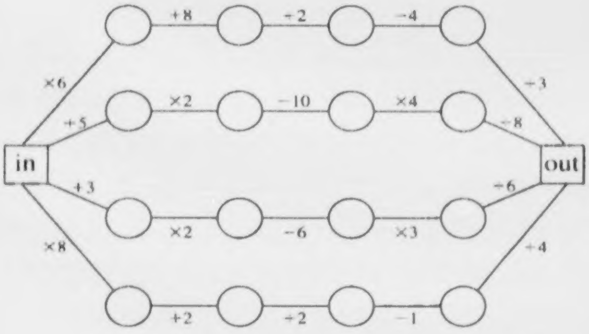
The 80 percent of our student population that now graduates from high school must be able to balance a frantically paced, technology-laden life. They must be expert problem solvers. They must have experience in working productively as part of a team, in discovering that there often is more than one "right" answer, in formulating alternate approaches to mathematical problems.

Certainly the acquisition of math facts is necessary, but without a broader view of the place mathematics holds in our lives, merely learning the basic skills is not enough. Asking students to learn math skills without concepts will have about as much impact on their ultimate literacy as asking them to learn to spell the word "elephant" without ever giving them the opportunity to see one!

Figure 4.

Network News (for upper elementary/ early middle school grades)

Here is a special kind of network — any number that goes into the in box gets changed around in complicated ways. Finally the number that comes out of the out box is the same as the number that went in.



1. Try this network, putting several different numbers into the in box and following along each of the four different paths from in to out. Do you always get out the same number you put in?
2. Can you add another path to this network that starts at the in and goes to the out box without changing the original number?
3. Explain how you think this network works.

Photo by Patricia Haley

Joan M. Kenney is co-director of the Balanced Assessment Program at the Harvard Graduate School of Education. Previously, she worked as a research scientist and taught mathematics at the secondary and college levels. She consults with several urban districts on issues of mathematics education reform and program evaluation. Included in her activity at Harvard is task design and student performance evaluation, outreach to community stakeholders, and service on the Mathematics Task Force of the Massachusetts Board of Higher Education. Email: joan_kenney@harvard.edu

References

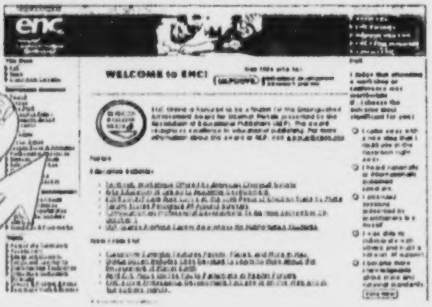
Schwartz, J.L., Kenney, J.M. et al. (2000). *Balanced Mathematics Assessment for the 21st Century.* (CD-ROM). Cambridge MA: Harvard Graduate School of Education. (ENC-019277).

'Old Math' fans should go forth and multiply. (2001, August 21). *Boston Herald*, P. 21.

JUMP ONLINE!

For more information about the Balanced Assessment Program at the Harvard Graduate School of Education visit the web site (balancedassessment.gse.harvard.edu). You will be able to download tasks, solutions, and rubrics for all grade levels, and will find some newer publications that were not included on the original CD-ROM *Balanced Mathematics Assessment for the 21st Century.*

JUMP ONLINE!



Visit ENC's Web Site

enc.org

ENC Online is designed to make the resources of the Eisenhower National Clearinghouse available to educators everywhere all the time. Here is a quick introduction to the site. We urge you to "jump online" and discover for yourself how helpful enc.org can be to you.

Curriculum Resources. In this area of the site, you can use two search formats to locate all types of teaching materials in ENC's collection of more than 20,000 items. The searches allow you to choose particular subject words, grade level, cost, and type of material to find exactly what you need for your classroom.

Web Links. Check this category for ENC's popular Digital Dozen feature, a monthly selection of exemplary math and science web sites. Web Links connects you to hundreds of sites with math and science lesson plans. A search feature helps you find Internet resources quickly and efficiently.

Professional Development. This portion of the site is designed as a teachers' professional support system. *By Your Own Design: A Teacher's Professional Learning Guide*, a joint project of ENC and the National Staff Development Council, is available here. This section also provides links to the national mathematics and science education standards, and state frameworks are listed conveniently by state. Federally funded resources and professional development strategies are also available in this section.

Topics. Hundreds of articles, teacher interviews, and selected curriculum resources are arranged thematically in this area. Topics include inquiry and problem solving, implementing technology, equity and diversity, and assessment. All of these topics provide content developed for *ENC Focus*, as well as useful web site and journal articles.

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2002 FINALIST
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ENC is honored to be a finalist for two Distinguished Achievement Awards presented by the Association of Educational Publishers (AEP). ENC Online is a finalist in the Internet Portals category, and the online version of *ENC Focus* is a finalist in the E-zines category. Distinguished Achievement Awards recognize excellence in educational publishing. For more information about the award or AEP, visit www.edpress.org

NASA Reaches Out to Teachers

Two television series from NASA engage elementary and middle school students while providing content support for their teachers.

by Terri Payne Butler, Lexington, Massachusetts

Hampton, Virginia:

"The first time I taught electricity I was a little apprehensive about jumping right in," says Mike Young, fourth-grade teacher at Francis Asbury Elementary School. "I didn't have a lot of background information in the subject, and I didn't know, for example, about the connection between electricity and magnetism. Working with the NASA SCIence Files gave me both the background and the activities to make the subject easier to teach."

About to begin its third season of programming, each episode of the SCIence Files series follows an intrepid band of youngsters—The Tree House Detectives—as they take on real-world scientific challenges. From investigating changes in the local fishing industry to learning why neighborhood dogs bark early in the morning and late at night, the group uses scientific inquiry to track down answers.

The series, produced at the NASA Langley Research Center in Hampton, Virginia, is rooted in national standards and integrates mathematics, science, and technology for third to fifth graders. The primary goal is to help youngsters become critical thinkers and problem solvers. An educator's guide and a program web site (scifiles.larc.nasa.gov) support teachers using the program.

Says Young, "I use the video to drive the curriculum, spending two to three days on each 15-minute segment from the one-hour program. There's a lot packed into those 15 minutes. After we watch, we talk about what we've seen and then do some of the hands-on activities ourselves before we move on to the next segment."

Young turns to the web site to select the activities that best meet his curriculum needs. The site's educator's guide offers plans for in-class, at-home, and online activities, as well as vocabulary words and print and online resources. When his students work on "The Case of the Electrical Mystery," they have the opportunity to do everything from investigating simple and complex circuits or building a solar cooker to exploring the effects of static electricity.

Young adds, "It's especially important to me that the video opens with a real-life problem. The answers are never obvious. The show goes through a lot of dead ends, and the kids on the program bounce ideas off each other just like scientists in real life do. My students are excited about the video, but they're most excited about getting their own hands on some of the activities we see happening on the screen."

Hitchcock, Texas:

At the Gulf Coast Christian School, Principal Margie Franklin uses NASA SCIence Files to enhance curriculum. "We're a unique school with a lot of individualized learning," says Franklin. "Most of our students finish their academic work in the morning, and in the afternoon they pursue subjects they are especially interested in. That's when they can pull out

Photos, provided by Chris Giersch, show NASA scientists visiting a classroom one of the videos and study science and math on their own."

Franklin adds that the program has broadened her knowledge of science and how best to teach it. "I'm a math person," she says. "It really does help me to have more ideas for the science part of these lessons. And this is a curriculum enhancer that doesn't cost a fortune. For us as a small school in a low-income community, it's a way to open doors for our students and let them explore on their own."

Franklin often has as many as four groups of students working together on different episodes from the series. "The program meets individual needs. For students who tend to rush through information, it's a way to put learning into action; for students with some learning disabilities, it meets auditory and tactile learning styles.

"In small groups, there's the chance to brainstorm and support each other in tackling a problem such as 'how do we complete this circuit?' or 'how do we make this switch work?' Sometimes they come up with a wrong conclusion and have to retrace their steps to figure out what happened."

Newport News, Virginia:

"Part of my job is helping students be better prepared for the technology demands of tomorrow's job market," says Lynn Chappell, a math teacher at Hines Middle School. "Our challenge as educators is to use all the resources we can find to help our kids become a nation of thinkers, readers, learners, and valuable citizens. NASA CONNECT helps me do that."

Similar in purpose and format to NASA SCIence Files, NASA CONNECT is created for middle school students. The program is now in its sixth season. Endorsed by the National Council of Teachers of Mathematics, NASA CONNECT establishes a connection between the math, science, and technology used in the middle school classroom with that used everyday by NASA researchers.

Chappell usually shows an entire 30-minute episode in her classroom after introducing a topic to her students. "I give them some background on what they're going to be seeing and at various points I stop the tape and use the student cue cards I've downloaded from the web site (connect.larc.nasa.gov)."

Says Chappell, "We discuss the questions together, and the answers are open ended. The real-life math they see on the program helps them understand why they need what they're learning, and the fact that the math application is often cutting-edge research really appeals to them."

Chappell also recommends previewing each episode so teachers can adapt it to individual classroom needs. "I can immediately tell if I might need to prep sixth graders more for a particular program than I would eighth graders. The web site activities also offer a great way to explore and strengthen skills I want them to have, and I appreciate that every activity lists the national standard it meets."

Chicago, Illinois:

At Bright School, teacher Joy Reeves is also a fan of NASA CONNECT's web site activities. "Most of my kids don't have a computer at home and each time they get to go on the computer, their faces are so intent," says Reeves. "Whether they're designing an airplane wing or practicing docking maneuvers from the episode on the International Space Station, they know these are not games—this is real."

Last year Reeves's sixth graders built wind tunnels out of washing machine boxes and then tested different polyhedron shapes to discover which created the most drag.

"I learned a lot from the activity, too," says Reeves. "I knew that shape had something to do with the efficiency of cars and trucks, but doing the wind tunnel experiment put it into perspective for me. It showed me in concrete form the effect of a shape and how it decreased or increased drag."

She continues, "When my students collected data and graphed it and compared it with other graphs, they didn't look on what they were doing as math—they were inspired to solve a real life problem, not just something out of a book."

Reeves says her students benefit from the growth in her knowledge of science. "The Internet docking activity that was part of the program on the International Space Station gave me a real 'ah-ha' moment when I witnessed and slowly understood that the scheduling of launch windows is based on the time it takes for an object moving in a smaller orbit to become parallel with an object moving in a larger orbit.

"In some ways, I've become the 'science expert' at Bright School because this program helps me proceed with confidence while others are still a bit leery. And my students are now the 'space experts' and can answer with authority questions posed to them by other teachers."

Reeve adds, "NASA scientists and engineers have put together lessons that children can understand, and it's free for us to take advantage of and learn from ourselves. My students are going to be paying taxes to send spaceships to Mars someday. I want them to know for themselves that project is exciting and worthwhile."

Terri Payne Butler, a freelance writer from Lexington, Massachusetts, reports on education and technology for national publications and web sites. She has a background producing children's television programs. For more information about NASA SCIence Files, email Shannon Ricles (s.s.ricles@larc.nasa.gov); for NASA CONNECT, email Chris Giersch: (c.giersch@larc.nasa.gov).

More About NASA's Free Instructional Programs

NASA SCIence Files for grades three to five and NASA CONNECT for grades six to eight both support the national mathematics, science, and technology standards. In both programs, episodes have three components:

- a television broadcast that can be viewed live, taped for later use, or acquired on video for $10 per tape
- a companion educator's guide available online
- an interactive web site featuring a problem-based learning activity that enables students to further explore topics presented in the program

Both SCIence Files and CONNECT are U.S. government products and not subject to copyright. There are no fees or licensing agreements, and broadcast and off-air rights are unlimited and granted in perpetuity.

2002-2003 Broadcast Schedule

Visit the related web sites for descriptions of the programs and a list of related educational standards. (R) indicates a repeat show from the 2001-2002 season.

NASA SCIence Files (scifiles.larc.nasa.gov)

The Case of the Powerful Pulleys
Starts airing: September 25, 2002, 11 am ET

The Case of the Mysterious Red Light (R)
Starts airing: October 16, 2002, 11 am ET

The Case of the Shaky Quake
Starts airing: November 20, 2002, 11 am ET

The Case of the "Wright" Invention (R)
Starts airing: December 11, 2002, 11 am ET

The Case of the Barking Dogs (R)
Starts airing: January 22, 2003, 11 am ET

The Case of the Inhabitable Habitat (R)
Starts airing: February 19, 2003, 11 am ET

The Case of the Biological Biosphere
Starts airing: March 19, 2003, 11 am ET

The Case of the Phenomenal Weather (R)
Starts airing: April 9, 2003, 11 am ET

The Case of the Galactic Vacation
Starts Airing: May 14, 2003, 11 am ET

NASA CONNECT (connect.larc.nasa.gov)

Geometry and Algebra: The Future Flight Equation (R)
Starts airing: September 26, 2002, 11 am ET

The Centennial of Flight Special Edition. Problem Solving: The Wright Math
Starts airing: October 17, 2002, 11 am ET

Data Analysis and Measurement: Having a Solar Blast! (R)
Starts airing: November 21, 2002, 11 am ET

Measurement, Ratios, and Graphing: Who added the "micro" to gravity?
Starts airing: December 12, 2002, 11 am ET

Functions and Statistics: Dressed for Space (R)
Starts airing: January 23, 2003, 11 am ET

Special Edition: World Space Congress 2002. The New Face of Space
Starts airing: February 20, 2003, 11 am ET

Measurement, Ratios, and Graphing: Safety First (R)
Starts airing: March 20, 2002, 11 am ET

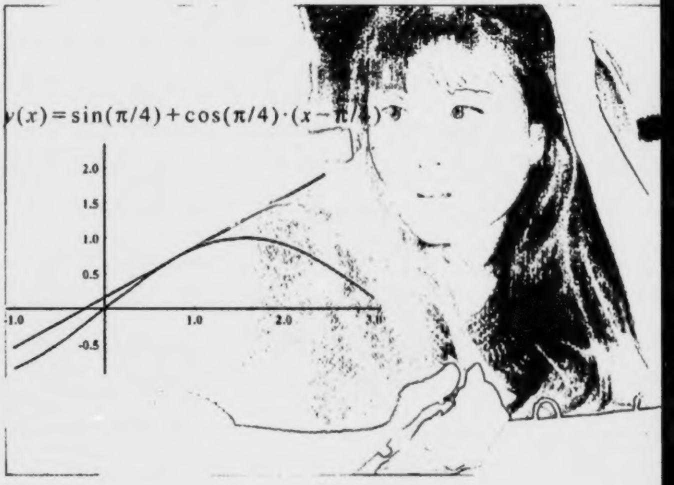
Data Analysis and Measurement: Dancing in the Night Sky
Starts airing: April 10, 2002, 11 am ET

Festival of Flight Special. Opening Space for Next Generation Explorers
Starts airing: May 15, 2002, 11 am ET

A Steep Learning Curve

An Eleanor Roosevelt Teacher Fellowship enabled a mathematics teacher and a physics teacher to deepen their own understanding and team up to improve student learning.

by Tina L. Coplan, American Association of University Women Educational Foundation



I'm not ashamed to admit it. I have a B.A. in mathematics, an M.A. in math education, and now I'm a doctoral candidate at Drexel University, and it took this experience [teaching reform calculus] for me to realize that I never really understood calculus. Oh sure, I could solve problems with the best of them, but I did it just for the sake of doing. I realized that I was never taught calc. It was shown to me. As a result, for the first six years of my teaching career, I 'showed' calc. I did not teach it.

—Denise Tabasco

After six years teaching traditional calculus at the college and secondary levels, in 1998 Denise Tabasco joined the faculty at Haddonfield Memorial High School in Haddonfield, New Jersey, where she started teaching "reform" Advanced Placement (AP) calculus. A radical departure, the new curriculum presented a comprehensive verbal and visual approach to problem solving, rather than the standard method of performing calculations.

"I really fought it," Tabasco recalls. "I took the textbook home and said, 'No way! This is too wordy. Where are the math problems?'" But, assured that she could return to the traditional approach if it didn't work out, she gave it a try.

It didn't take long for Tabasco to become an advocate. The students' performance improved dramatically, and Tabasco herself achieved a new level of awareness. "I really got it as I taught it to the kids," she says. "As the material built, it began to make sense to me. For the first time in my life, I almost felt inside the math problem instead of number crunching just to get a correct solution. I gained a level of understanding that still amazes me."

Support for Professional Growth

To spread the success, Tabasco joined with physics teacher Mary Barth in 2000-01 to develop a calculus-based physics program. The innovative project was supported with an Eleanor Roosevelt Teacher Fellowship from the American Association of University Women (AAUW) Educational Foundation.

The fellowship enabled both teachers to attend conferences to advance their professional growth. Tabasco learned about the origins of reform calculus through a course in contemporary issues in education. She also joined the Women in Mathematics Organization while attending a conference of the National Council of Teachers of Mathematics. Barth attended an AP Physics Institute conference that helped her evaluate the physics portion of their course.

A steep learning curve was required to teach both the reform calculus and new physics programs. Tabasco describes her homework to re-learn calculus: "I would work about two hours a day prepping just for this course. It consumed me that entire year. It wasn't until my 'ah-ha' moment that I stopped hating the prep time. I actually looked forward to it."

The Eureka Moment

Tabasco's eureka moment occurred in mid-December, while she was writing on the board. A student asked a question, she answered, then another student posed a different scenario, and she answered that too. A classroom discussion began.

"I just stood there looking at these kids and couldn't get over the fact that they were not only accurate, but passionate about what they were debating," she recalls. "They were talking mathematics and posing questions at a level I never experienced as a student or a teacher. Then the second huge realization hit. For the first time in my experience, the girls were interacting as much as the boys. I couldn't believe it."

A Sample Problem for a Calculus-Based Physics Class

This problem, developed by Denise Tabasco and Mary Barth for their integrated calculus and physics course, demonstrates their more verbal approach to teaching these subjects together. Illustrating the concepts of displacement, velocity, and acceleration, the problem is used during the first month of school.

A particle moving along the x-axis so that its acceleration at any time t is represented by $a(t) = 6t - 4$. At time $t = 0$ s, the velocity of the particle is $v(0) = -5$ m/s, and at time $t = 2$ s, its position is $x(2) = -4$ m.

a) Write an expression for the velocity $v(t)$ of the particle at any time t.

b) Write an expression for the position $x(t)$ of the particle at any time t.

c) For what values of t is the particle at rest?

d) At time $t = 2$ s, is the particle's velocity increasing or decreasing? Please explain.

e) At time $t = 2$ s, is the particle speeding up or slowing down? Please explain.

f) Find the net displacement between $t = 0$ s and $t = 5$ s.

g) Find the total distance traveled between $t = 0$ s and $t = 5$ s.

h) Show in full detail, with visual and written explanations, why the values found for displacement in part (f) differs from the value found for distance in part (g).

A key difference in teaching the reform method, she points out, is that "we don't tell students what to do. We're coaches guiding them through as they make connections and gain knowledge. We're talking and communicating, also using the graphing calculator to help them visualize a curve, hitting all different learning styles so you can't miss. I don't 'show' calculus any more, I teach it. It's exciting to be in the classroom."

Before Tabasco started teaching reform calculus at Haddonfield, fewer than five students each year took the AP calculus test. In the four years since she began teaching the course, numbers have jumped into the 20s. And many of her graduates, because of their high AP test scores, start Calculus II in college. Both boys and girls now say that calculus is their favorite class.

Taking Responsibility

After her first year of teaching the new method, Tabasco reached out for additional coaching for herself. She attended a one-week workshop in California to explore the textbook she was using, *Calculus* by Paul Foerester. The workshop was held by the textbook publisher, Key Curriculum Press, and run by the book's author. While the school paid for the conference, Tabasco paid nearly $1,000 for travel and expenses. She also attended several one-day local AP calculus conferences as well as another workshop the following summer. Tabasco believes that taking the classes after teaching the subject provided a deeper understanding.

Creating the calculus-based physics class required Tabasco to learn physics and Barth to learn calculus. Tabasco uses physics examples in teaching calculus and Barth integrates calculus while problem solving in physics. Having completed two years, they still have found no guideposts, models, or textbook for their new course. "We've searched the country and the few schools that we've found coordinate, but don't integrate, calculus and physics," notes Tabasco. As a result, the teachers have developed their own workbook, which they hope to publish. (See box on this page.)

Tabasco feels the expenditure in time, money, and effort to learn the reform approach to calculus was worth it, but she adds, "We need schools to assist with the expenses of such a transition." As the result of her efforts, Tabasco believes more firmly than ever that "educators, at every stage of their careers, have the responsibility to change."

Tina L. Coplan is an editor for the American Association of University Women Educational Foundation. For a previous issue of Focus, *she wrote an article about other teachers who have benefited from Eleanor Roosevelt Teacher Fellowships; it is available online (enc.org/focus/equity). Email: ertf@aauw.org*

The AAUW Educational Foundation provides funds for female public school teachers' professional development and to encourage girls' interest in math, science, and technology. The deadline for 2003-04 applications is January 10, 2003. For more information and an application (available August 1), visit www.aauw.org or call (319)337-1716.

ENC is hosting an online discussion of this article. Join other educators talking about questions such as this:

DISCUSS

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Visit enc.org/focus/content/discuss

Essential Science in Elementary School

A free telecourse is being developed to help elementary teachers build science content knowledge that has relevance in their classrooms.

by Sue Mattson, Science Media Group, Harvard-Smithsonian Center for Astrophysics, Cambridge, Massachusetts

"Quick! Bring the camera! I see a bird!" shouts Maria.

Roderick points excitedly at a large oak tree. "We found a bunch of living things!"

"Look!" says Maya. "There's a squirrel, and ants, and green stuff on the trunk, and we found mushrooms behind it, and some seeds too!"

"The seeds aren't alive," claims Mikael. "They fell off the tree, so they're dead, just like this," he says as he waves a broken twig at Maya.

Jonathan runs over to a puddle. "What about this?" he asks. "The water's moving! And there might be tadpoles in here."

"Yeah," agrees Enrico as he kicks some sand in the puddle. "And, the sand's alive too, because it came from a rock."

"Take pictures for our collection," Mei Ling reminds you. "That way we can remember what we found!"

Never a dull moment with these students, you think. They've done quite well on a field trip to discover what's living in their own playground. And they always find something that becomes a challenge for you in helping them learn what "life" is. As you follow the children and snap pictures, you think about the activities you have planned for the next few days. What do you know that will help students build scientifically accurate answers to the question "What is life?"

—From *Essential Science: Real Classrooms*

Finding life on a playground? Not a problem, especially for elementary school children! Children are wonderful observers of their surroundings and are fascinated by even the most familiar living things. This is especially true when they are encouraged to look at things in ways that scientists do, to ask their own questions, and to shape their own answers.

The problem, more often, is making sure that their understandings are scientifically accurate. To do this requires teachers to have their own sound understandings of core science concepts. How can teachers build science content knowledge that has relevance in elementary classrooms?

We can learn a lot from simply doing activities alongside our students. What they say, what they do—their questions and confusions—can alert us to our own need to know more. We can begin to fill that need by reading, watching science programs on television, attending workshops, or just getting out into the world to explore.

Imagine that you had a camera that would let you zoom in and look at the smallest parts of things. What would you see? Picture a bird in an oak tree. Focus on the bird with your camera. Now, zoom in so close that you are inside a patch of feathers on the surface of its skin. You find yourself in a world teeming with life. You hide from huge insects prowling among the feathers—are they mites? Look! There are different kinds of insects on different parts of the feather! You zoom in closer, and you enter an even stranger world. Huge rods and spheres form a mosaic on the bird's skin. Is this what bacteria look like? You wonder what surprises the surface of an oak leaf harbors. You zoom out with your camera and back to the world of the familiar. Or is it?

—From *Essential Science:. It's Alive!*

The world can become our own playground for learning science simply by looking at it in different ways. But how do we tailor our learning to the needs of K-6 children? One way is to look at research on children's ideas and how these ideas change through well-planned experiences. We can also learn by doing our own research.

Classroom activities can be structured and used to identify "critical incidents" that reveal gaps in our own content understandings. Identifying these gaps can help us focus our goals for our own learning and guide us as we explore science content in the interest of improving our students' learning. In our explorations, there is no substitute for the "real thing"—actively thinking about and doing science.

All of these learning techniques are addressed in different components of *Essential Science*, currently in production by the Harvard-Smithsonian Center for Astrophysics. The shaded boxes throughout this article suggest how these components might be portrayed in different video segments in a typical *Essential Science* program.

Children come to school with a lot of ideas about what it means to be alive. Research literature describes the following ideas held by children at various ages (Driver et al., 1992):

- Anything that moves is alive, and only those things.
- Only things that eat, breathe, and/or grow are alive.
- Animals are alive but plants are not.
- Seeds and eggs are not alive.

What understandings do children in your classroom have about what it means to be alive? How do your understandings compare with theirs? What knowledge is necessary to move children from ideas like those above to ideas that are more scientifically accurate?

—From *Essential Science: On Their Minds—Research on Children's Ideas*

Essential Science has the goal of helping K-6 teachers enhance their understandings of the bedrock ideas that underlie science in the elementary school curriculum. Funded by Annenberg/CPB, *Essential Science* is a series of three television-based courses, one course each for life science, Earth/space science, and physical science. The topic areas are drawn from the National Science Education Standards and Project 2061's Benchmarks for the elementary grades.

Each *Essential Science* course is built around eight one-hour shows. Beginning in winter 2003, courses will be broadcast in recurrent cycles on the Annenberg/CPB Channel. The channel, which features professional development programming in numerous curriculum areas, is a free satellite/web service and can be accessed by more than 61,000 schools and 38 million households across the country.

Viewers are encouraged to videotape programs, which are in the public domain. In addition to the broadcasts, courses include print and web site materials containing suggested activities that can be tailored to the viewer's own goals.

(*Working together at a table.*)

Jusef: The bird is alive, and so is the leaf. I don't know about the seed.

Colin: The leaf isn't alive. It can't grow. Seeds can, so they're alive.

Jusef: But seeds don't move, so they can't be alive.

Colin: Well, what about water? It can move.

Jusef: Water's different. It's like this sand. It's dead.

Colin: The sand was never alive, so how can it be dead?

(*Addressing the group.*)

Ms. Rice: I can see that not all of you agree about what is living. Remember, we decided that each item could only be in one group. Why don't we look at the items we're sure of? Let's start with the bird, since everybody seems to agree that it's alive. What makes the bird alive?

Jusef and Colin are partners at The Science Place. They have an important job. Along with other children, Jusef and Colin are there, ultimately, to help teachers. As they progress through activities drawn from research-based science curricula, the staff at The Science Place captures what they say and do on videotape. The curriculum developer, Ms. Rice, is on hand as an activity guide and to bring critical incidents that relate to understanding core science concepts to the foreground. Jusef and Colin thus help by identifying "jumping off" points for further content exploration by teachers.

—From *Essential Science: The Science Studio—A Place to Learn from Learners*

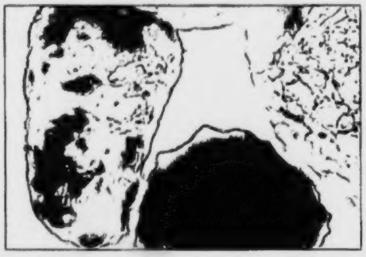
Essential Science courses are developed for graduate-level credit, and the producers are working out the details. Those taking the course for graduate credit will be introduced to the science education research literature and will be asked to apply what they learn in their own classrooms.

Of course, viewers may use *Essential Science* courses in a variety of ways: as electives in undergraduate coursework, in professional development workshops, or simply to help individuals build better science understandings.

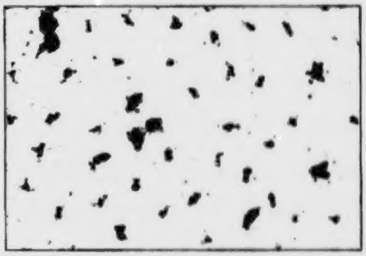
For more information on tuning in to *Essential Science* or the Annenberg/CPB Channel, please email channel@learner.org or visit the web site (www.learner.org). Upon completion in fall 2003, *Essential Science* videos will be available for purchase through Annenberg/CPB at 800-LEARNER.

Look closely at the micrographs below. What similarities do you see? What differences do you see? What can you conclude about living things?

(A) leaf epidermis



(B) sand



(C) frog epidermis

Videographs by John Dean

In the mid-1600s, Anton van Leuwenhoek was one of the first people to use a microscope to study nature. In a drop of pond water, he discovered a bounty of living things too small to be seen by the naked eye. Robert Hooke looked at thin slices of plant tissue under a microscope, where he observed thousands of tiny chambers that he called "cells." By the mid-1800s, it had been confirmed that all plants and animals are made of cells, and cell reproduction had been observed. The cell theory was developed to explain these observations, and is a fundamental concept in biology. The cell theory states:

- All living things are composed of cells.
- Cells are the basic units of structure and function in living things.
- New cells are produced from existing cells.

How could you apply the principles in the cell theory to help students distinguish between living things, like plants and animals, and non-living things, like sand and water?

—From *Essential Science: Content Explorations for Teachers*

Sue Mattson is a curriculum developer for the Science Media Group at the Harvard–Smithsonian Center for Astrophysics. She has taught science methods courses for preservice teachers in early childhood and elementary education, and was part of a team to develop a biology course specifically for elementary school teachers. Email: smattson@cfa.harvard.edu

Reference

Driver, R., Squires, A., Rushworth, P. & Wood-Robinson, V. (1992). Living Things. In *Making Sense of Secondary Science: Research into Children's Ideas* (pp. 17-27). London and New York: Routledge.

More Content Courses? Maybe Not!

This article from the Wisconsin Center for Education Research suggests that content courses leave preservice teachers with little understanding of how their students learn science concepts.

by Paul Baker, University of Wisconsin, Madison

Three essential components of a teacher's lifelong professional development are subject matter coursework, preservice teacher education, and inservice teacher education. Yet Wisconsin Center for Education Research (WCER) researcher Peter Hewson and colleagues Ken Zeichner and Robert Tabachnick see only weak relationships between these components in most science education teacher preparation programs. Ideally, these three components should be strongly connected.

The success of science teacher education programs depends on offering prospective teachers a coherent, integrated experience, according to the team's recent research. To understand how one program influenced the ongoing process of learning to teach, the team conducted case studies of several prospective elementary and secondary science teachers. The researchers sought to identify the successes and failures of the program's various components and how well its participants did in achieving its stated outcomes.

Underlying Assumptions Are Powerful

Prospective teachers' understanding of the nature of knowledge is a critical factor in their teaching. Most of the prospective teachers studied began their programs with a "transmissionist" view, believing that true knowledge exists, that it is independent of individuals, and that it can be transmitted or passed on to another person by using good explanations and demonstrations of scientific principles. The transmissionist view contrasts with a "constructivist" view, which sees knowledge as being constructed in students' minds as they draw on their prior knowledge to make sense of new experiences.

All the prospective teachers developed an interest in their students' prior knowledge over the course of their student teaching experience. However, the prospective teachers viewed the affective function of considering students' views as more important than its cognitive function. In other words, they saw the value of eliciting students' ideas in contributing to a supportive, inclusive classroom atmosphere but downplayed the significance of students' ideas leading to conceptualization of intended curricular outcomes.

Interviews with prospective teachers indicated that their understanding of biology and life science tended to be based on a static, relatively disconnected collection of facts. The major difference between the prospective elementary and secondary teachers was the quantity of information they knew.

It is often said that an effective way of learning a subject is to teach it. Accordingly, Hewson, Tabachnick, and Zeichner had anticipated that classroom practice would give young teachers a deeper and more coherent understanding of content knowledge. Yet the final interviews provided little evidence that this was the case. There was an increase in prospective teachers' confidence in, and familiarity with, their own knowledge. But the change appears to have been largely affective—it made them feel good about their level of knowledge. Teaching did not seem to lead the prospective teachers to a greater coherency in, and a deeper understanding of, their content knowledge.

The research team found that teachers coming into the program knew little about the methods of inquiry used within the discipline of biology. This left prospective teachers without an understanding of the role of theory in biology and the way in which scientists use theory to pose problems and construct new understandings. The conceptual change model of teaching and learning emphasizes the importance of making class time for their students to consider the relative status and value of alternative conceptions. The conceptual change approach uses theory development in science as a metaphor for how individuals construct new conceptions.

Prospective teachers need to understand theory development in science. Without it, they will be ill-equipped to help their students evaluate the relative status of scientifically accepted conceptions and other potential competing conceptions the students bring to the classroom.

Amount vs. Coherence of Knowledge

The content courses taken by the prospective teachers in this study prepared them to do little more than transmissionist teaching. While this might be expected for prospective elementary teachers, it was also the case for secondary candidates. Prospective secondary teachers' conceptual understanding was, by their own accounts, inadequate for teaching at the high school level, and probably also at the elementary and middle school levels. The problem had less to do with what they didn't know than with the lack of coherence of what they did know.

Hewson, Tabachnick, and Zeichner believe the lack of coherence results from college science teaching and assessment strategies that do little to emphasize the integration of course content. For example, the lecture setting seldom encourages students to think about and relate concepts to each other, and multiple-choice tests ask for information in a piecemeal fashion.

More Coursework in the Major?

It is often suggested that, to improve content knowledge, prospective teachers should take more courses in the academic disciplines, often at the expense of education courses. This study, along with much of the existing data on the preparation of teachers in the arts and sciences, shows instead that an academic major, as currently taught, does not seem to guarantee deeper conceptual understanding than an education major (McDiarmid, 1994).

A key factor for prospective teachers in this study was their lack of understanding of how scientific knowledge is produced, what role theories play within the discipline, how those theories are revised, and especially what problems those theories were developed to solve. Teachers' methods courses in this study gave them some awareness of their students' conceptions, but their content courses left them without an understanding of how those conceptions could be tested and revised like scientific theories. This points to the need for significant changes in the curriculum and instruction of content courses, ideally arising from dialogue between science educators and their colleagues in the arts and sciences.

Recommendations

The research led to the following additional conclusions about how preservice teacher education could be strengthened.

Prospective teachers would benefit from methods courses that offer more comprehensive perspectives on how students learn, and teachers teach, science. Such courses would provide prospective teachers with a richer variety of opportunities to learn how to teach science. In addition, science teaching methods should be revisited after prospective teachers complete their student teaching. This review could help them tie together classroom experiences with their emerging constructivist conceptions about important issues such as the nature of scientific knowledge, science, and learning.

Student teaching experiences likewise need to be reevaluated. Probably the most important role here is that of the cooperating teacher in the student teaching placement. The cooperating teacher is a powerful role model; his or her beliefs and teaching approaches can significantly influence the direction of a prospective teacher's development. "We fault ourselves for not doing more to engage cooperating teachers in the task of reconceptualizing the practices of science teaching and science teacher education," says Hewson.

WCER Highlights

More content courses? Maybe not

Underlying assumptions are powerful

Time for reflection was also in short supply. Time constraints prevented the prospective teachers from adequately reflecting on their student teaching experiences. There is little reason to believe that they will have more time when they enter their first year of regular classroom teaching. It may be beneficial for prospective teachers to teach fewer sections during their student teaching and use the extra free time to reflect more deeply on their lessons.

For more information contact Hewson at pwhewson@facstaff.wisc.edu or call 608-262-1665.

Paul Baker is editor of WCER Highlights, *newsletter of the Wisconsin Center for Education Research at the University of Wisconsin, Madison.*

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Reference

McDiarmid, G. W. (1994). The Arts and Science as Preparation for Teaching. In K. Howey & N. Zimpher (Eds.), *Faculty Development for Improving Teacher Preparation* (pp. 99-138). Reston, VA: Association of Teacher Educators.

Formulating Formulas: The Making-a-Mess Method

Through an exploration deriving formulas for volume and surface area, students and teachers gain mathematical understanding and confidence.

by Anne C. Patterson, Mainly Math, Inc., DeLand, Florida

Looking more like a pack mule than a middle-school math teacher, I entered my toughest class—a group of reluctant learners who had met with little success in previous math courses. Loaded down with bags of gumdrops, toothpicks, potato chip cans, wrapping paper, centimeter cubes, cereal, plastic boxes, cylinders, and cones, I dropped my supplies on the old table in my classroom, turned to the students, and began my review of their homework assignment. Soon overcome by curiosity, my students interrupted me to ask, "Aren't we going to do something with all that stuff on the table?" Now that I had captured my students' attention, I told them we were embarking on a three-day discovery unit called Formulating Formulas. (As we got into the unit, my middle schoolers dubbed it "Making-a-Mess!")

According to NCTM, hands-on geometry explorations help students become "curiously interested in what comes next" (NCTM, 1996, p. 1). I decided the Making-a-Mess method would do just that, while helping my kids develop their own algorithms for volume and surface area, deriving the formulas as they worked. In addition, many of my students were "concrete thinkers who require visual stimulation to perceive relationships...and benefit from the visual support that manipulatives provide" (NCTM, 1996, p. 1). Again, Making-a-Mess seemed a perfect fit to address the needs of my students.

The class began the exploration by building space figures with gumdrops and toothpicks (Figure 1). Knowing that vocabulary would be important to my students' success in this unit, I used their three-dimensional creations to review the terms *base*, *face*, *vertex*, and *edge*. My ultimate goal was to help my students derive the formulas for volume and surface area using hands-on materials. Because many of them had memorized some of these formulas in previous math courses, usually with little understanding, I was careful not to mention the words *volume* or *surface* area yet.

For Teachers, Too

I sometimes use these very same explorations with teachers to help them increase their content knowledge. At workshops I present at math conferences and school districts, I watch as middle-school math teachers build, pour, and predict, taking delight in rediscovering the meanings behind the memorization. Teachers who had anxiously approached the teaching of volume and surface area gain confidence and are excited to share the formula explorations and their deeper understanding with their students. To deepen your understanding of volume and surface area, see the sidebar on page 42 for some refresher facts about the formulas used in these activities.

Exploring Area and Volume

Figure 1.

The next day, I divided the class into groups of three or four students and gave each group a lidless, rectangular box, a handful of centimeter cubes, an overhead transparency, and a transparency pen. "Your job," I announced, "is to figure out how many cubes will fill this box. Then, write your solution on your transparency explaining how you figured it out, and present your thinking to the class." Once the kids understood the directions, I was free to wander and watch as they worked ... and worked ... and worked.

Kayla, Jeremy, Vicki, and Carlos were the first to make their presentation to the class (Figure 2).

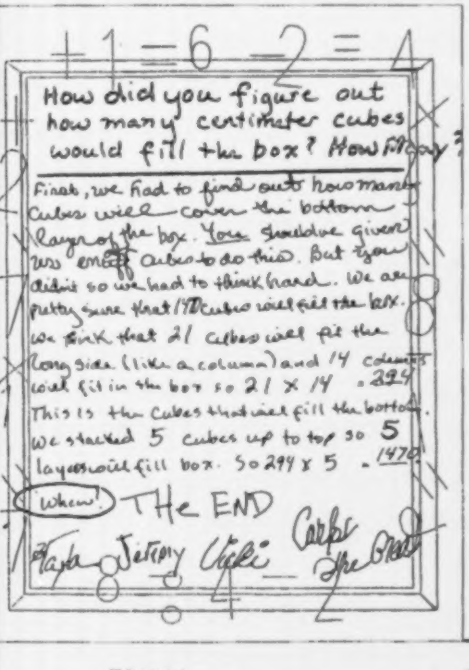
After all of the groups had presented their solutions to the class, I told them to remove the cubes and flip their boxes over. They found the graph paper that I had taped on the bottom of each box the previous evening. I had labeled one side length and one side width, and in the middle I had written Area of Base (B). (Figure 3) Counting the number of centimeters on the length and width, and then the square centimeters of the whole base, they suddenly realized that they had figured out the formula for the exact area of the rectangular base. Length (21 cm) multiplied by width (14 cm) equals the area of the base (294 cm^2).

I explained that the capital letter "B" is used in high school textbooks to represent the area of the base of a three-dimensional figure. Based on their experience with the cubes and boxes, the students agreed that the volume of a right rectangular prism could be expressed as $V = (B)h$. By substituting (lw) for (B) in the formula, they decided that the volume could be written as $V = lwh$. It was a familiar formula, but one that held more meaning for the kids because they had figured it out themselves.

From Boxes to Cylinders and Cones

Next, I held up a plastic cylinder and asked, "How would you determine the volume of this cylinder in cubic centimeters?" The students decided that they would need to know how many cubes would fit in the bottom layer of the cylinder and multiply that number by the height of the cylinder (Figure 4). This time, however, it would prove to be more difficult to determine the number of cubes in the bottom layer because the base was a circle instead of a rectangle, so the cubes would not fit exactly. After turning over the cylinder and again finding a piece of graph paper taped to the base, cut into the shape of a circle this time, they knew how to proceed. The graph paper reminded the students that the area of a circle, the base, was equal to πr^2. The volume of this cylinder could also be represented by the general formula $V = (B)h$. So, by substituting πr^2 for (B) in the formula, the volume of a cylinder must be $V = \pi r^2 h$. Not so difficult after all!

Figure 2.



+1 −6 −2 = 4

How did you figure out
how many centimeter cubes
would fill the box? How many?

Final, we had to find out how many
cubes will cover the bottom
layer of the box. You should've given
us enough cubes to do this. But you
didn't so we had to think hard. We are
pretty sure that 1470 cubes will fill the box.
We think that 21 cubes will fit the
long side (like a column) and 14 columns
will fit in the box so 21 x 14 = 294
This is the cubes that will fill the bottom.
We stacked 5 cubes up to top so 5
layers will fill box. So 294 x 5 = 1470

Whew! THE END

Kayla Jeremy Vicki Carlos The Great

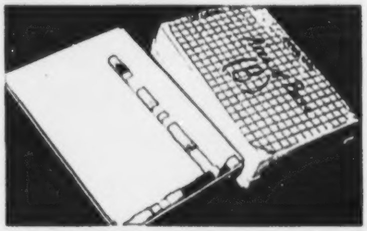


Figure 3.

Figure 4.

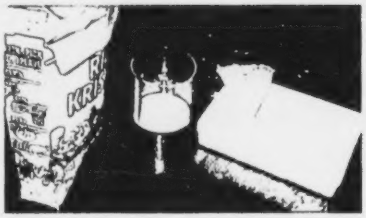


Figure 5.

I next distributed bags of cereal and cylinder/cone sets. With little hesitation, my students poured and spilled their way to the realization that the formula for the volume of a cone must be $V = \frac{1}{3}\pi r^2 h$ because it takes the volume of three cones to fill the cylinder (Figure 5). The students were noisy and the room was quite a mess after this last experiment, but I knew it was all worth it when I heard a previously unmotivated student mumble, "Pretty cool, Mrs. Patterson, pretty cool."

Food for Thought

Into our third day of formulating formulas, all eyes and hungry stomachs were focused on the table where potato chip cans were covered in colorful wrapping paper (Figure 6). I explained that their assignment was to figure out the formula for the area of the wrapping paper needed to cover the cylinder, knowing only its height (h) and the radius (r) of its base. My sleuths soon discovered that the cans had two lids covered with paper, one lid on the top and one lid on the bottom. Instinctively, the students removed all the wrapping paper and smoothed out two circles and a rectangle the size of the potato chip can's own label. There were two circles, each circle having an area of πr^2, so the kids quickly wrote down $2\pi r^2$.

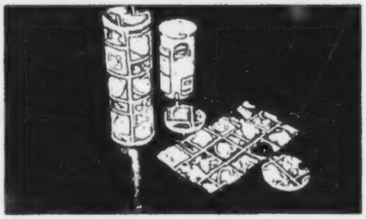


Figure 6.

The rest of the formula was more difficult, so we worked as a class to finish the problem. My students recognized that the width of the rectangle was equivalent to the height (h) of the potato chip can. But what did they know about the other dimension of the rectangle, its length? After some prodding, the class concluded that the long edge of the rectangular piece of wrapping paper fit perfectly around the circular lid of the can and must be equivalent to the circumference ($C = 2\pi r$) of the circular top. Using $2\pi r$ as the length and (h) as the width, they substituted these variables into the formula $A=lw$ and discovered that the area of the rectangular piece of paper was $2\pi rh$. Suddenly remembering to include the two lids, my triumphant mathematicians announced proudly that the surface area of a cylinder had the formula: $A= 2\pi r^2 + 2\pi rh$ (Figure 6).Then the students gobbled down the potato chips as their reward for three days of hard work! But the greatest reward was seeing all of the students involved, thinking, and curious about what we were going to do in math class tomorrow!

Building on a Solid Foundation

In deriving the formulas for volume and surface area through visual and tactile experiences, my students seemed to move from an intuitive understanding of these concepts to a higher level of geometric sophistication. They appeared to have developed a more solid foundation on which to build formula exploration, an essential ingredient for success in high school mathematics courses. According to Brian Butterworth, because the process of learning mathematics is so cumulative, if a student "fails to understand one stage, then anything that is built upon that stage is going to be rather fragile" (D'Arcangelo, 2001, p. 19).

Anne C. Patterson has 22 years of experience as a mathematics teacher and district specialist. She is author of Learning Around the Table *(*www.learningaroundthetable.com*) and serves as president, keynote speaker, inservice trainer, curriculum consultant, freelance writer, and author of instructional materials for Mainly Math, Inc., in DeLand, Florida (www.mainlymath.com.). Email: annepatterson@att.net*

References

D'Arcangelo, Marcia. (2001). Wired for Mathematics: A Conversation with Brian Butterworth. *Educational Leadership 59*(3), 14-19.

Fischer, Kurt W. & Rose, L. Todd. (2001). Webs Of Skill: How Students Learn. *Educational Leadership 59*(3), 6-12.

National Council of Teachers of Mathematics. (1996). *Addenda Series Sixth-Grade Book*. Reston, VA: Author.

What's in a Formula?

Bombarded with formula after formula, even veteran math teachers can benefit from a refresher-lesson on how the volume formulas came about and how they fit together.

The Building Block Volume Formula

$V = (B)h$

- The volume of a prism is the product of its base and its height.
- Mathematicians use a capital "B" to represent the area of the base of a prism and "h" to represent its height.

A Chip-Off-The-Old-Block

Right Rectangular Prism

$V =(lw)h$

- If the base of a prism is a rectangle (making the prism a right rectangular prism), the area of the base is lw. By substituting lw for B in the formula $V = (B)h$ the formula becomes $V =lwh$.

Cylinder

$V = (\pi r^2)h$

- If the base of a prism is a circle (making the prism a cylinder), the area of the base is πr^2. By substituting πr^2 for B in the formula $V = (B)h$, the formula becomes $V = \pi r^2 h$.

Cone

$V = \frac{1}{3}\pi r^2 h$

- By experimentation, a cone with height and circumference equal to that of a cylinder holds $\frac{1}{3}$ the volume of the cylinder. Since the formula for the volume of a cylinder is $V = \pi r^2 h$, the formula for the volume of the cone is $V = \frac{1}{3}\pi r^2 h$.

Try It Out for Yourself

Which glass holds more? A cylindrical glass with height 12 cm and radius 3 cm or a cylindrical glass with height 9 cm and radius 4 cm? What is the difference in volume? How would you explain the difference in volume to your students?

Where does "poly-water" come from, anyway?

A veteran teacher finds unexpected benefits from a graduate science course. Your own content knowledge may be sharpened by the misconceptions of her fellow students.

by Deanna Buckley, Delta Rural Systemic Initiative, Hattiesburg, Mississippi

It was a beautiful day as I walked across the University of Southern Mississippi campus to the second meeting of Biochemistry 421/521. Even though I was a seasoned high school science teacher, I was anticipating this long-awaited opportunity to increase my science knowledge.

The rural community where I live is 68 miles from the campus. In such a setting, science and mathematics teachers often become isolated. Online instruction has not been an option, and the university rarely offers challenging courses at a time when an employed teacher could attend.

My opportunity came in the form of the Delta Rural Systemic Initiative (RSI), a program funded by the National Science Foundation. As a field coordinator for the Delta RSI, I see isolation as a major problem for the teachers I serve. In Mississippi, as many as 50 percent of beginning teachers leave the profession within three years, and isolation probably contributes to their sense of frustration. Part of my job is to provide professional development and support to reduce this frustration. In a sense, I bring the university to rural teachers and help them learn to implement changes in their teaching. (See box on page 45.)

For me personally, working for the Delta RSI offered the chance to take graduate courses. However, Biochemistry 421/521 provided unexpected benefits.

That second day of class, our professor began by addressing misconceptions revealed in the pretest we took during the first class meeting. He focused on how members of the class had incorrectly illustrated a hydrogen bond, and he emphasized the importance of understanding this concept since it is the basis for many biochemical interactions. He painstakingly explained why each misconception was wrong. Figure 1 on page 44 illustrates some of the students' examples.

I was fascinated by the misconceptions, but my concentration was broken when I realized that a former high school chemistry student of mine was in the class. Bob greeted me warmly at the door as we were leaving.

Bob: Hey, Mrs. Buckley! What are you doing here?

Me: Taking biochemistry.

Bob: Why would you want to do that?

Me: Because I want to learn more. There have been so many biochemical discoveries since I graduated 18 years ago.

Bob: Oh. *(Looking puzzled.)*

Me: I noticed the professor already knows you by name. Have you been in his class before? (Hoping he had not failed the first time because his preparation in my class years before had been inadequate.)

Bob: Oh no. I have been working for him this summer, helping him figure out his new software.

I breathed a sigh of relief. Then I remembered how, four years earlier, Bob had helped to install and support hardware and software at our high school, actually teaching teachers how to use gradebook and attendance functions.

Bob: What lab section did you sign up for?

Me: Thursday.

Bob: *(Very loudly.)* Yay! I have found my lab partner!

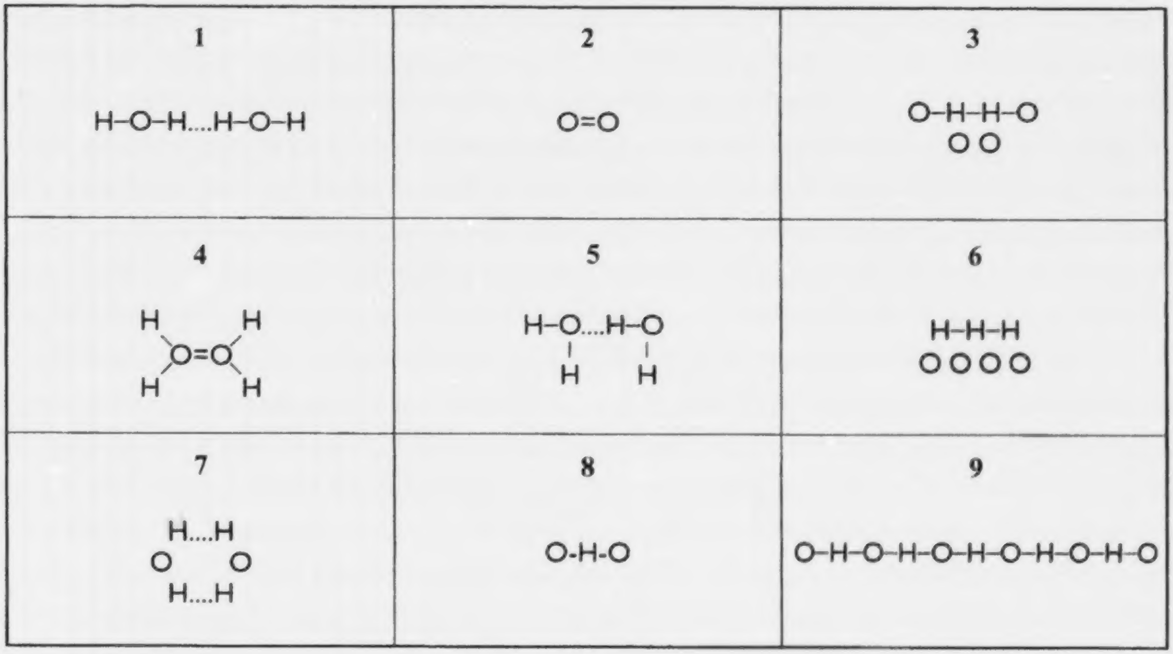
I was not sure whether to be flattered or cautious. I couldn't remember Bob's grades in my class and that worried me a little. In the middle of the 100 or so students, many half my age, who witnessed Bob's exclamation of unabashed loyalty, I blushed but decided it couldn't hurt to have a tech whiz as a lab partner.

Bob: Hey, where are you going now?

Me: Well, I wanted to look more carefully at the misconceptions from the pretest. I want to understand how people picture something they can't see. I guess I will always be a teacher at heart.

Figure I.

All but one of these student diagrams reveal misconceptions. Can you identify which illustration is the most accurate way to indicate the hydrogen bonding of water molecules?



Explanations of the misconceptions:

1. Although the formula is correct for water, H_2O, and it is illustrated with dotted lines to indicate an attraction to the other water molecule with a hydrogen bond, the partially positive nature of the hydrogen in the polar molecule would repel the other hydrogen and would not form an attractive hydrogen bond between the two hydrogen atoms. The electrons (negative) are more densely packed around the oxygen, which gives the hydrogen a more positive (less negative) partial charge although the net charge of the entire molecule is zero.
2. This is the structural formula for molecular oxygen, not water.
3. The formula for water is not HO_2. (Also see explanation for 1.)
4. Although the ratio of atoms is correct, an oxygen atom is bonded covalently with two hydrogen atoms, which is illustrated correctly by convention with a single solid line between the hydrogen and the oxygen in each water molecule. The oxygen atoms do not bond with a double covalent bond to each other when two water molecules are in contact. This would require more energy than is commonly available in simple aqueous contact.
5. The middle illustration shows the attraction of the hydrogen of one water molecule to the oxygen of another water molecule. The highly electronegative element oxygen has a tendency to be more negative (more electron dense), which makes the water molecule polar, meaning like a little magnet. Thus, the more positive hydrogen is attracted to the more negative oxygen. The dotted line illustrates the attraction, which is not as strong as a covalent bond but strong enough to give water its unique properties, such as surface tension, high heat capacity, and lower vapor pressure. Its solid phase is less dense than the liquid phase. This is the basis for many molecular interactions in living things. If you chose this option, you are correct!
6. See number 3.
7. See number 1.
8. See number 3.
9. Poly-water! Hydrogen and oxygen atoms do not bond covalently together in this pattern. Oxygen, having six electrons in its outermost shell and requiring only two more, which is supplied one from each hydrogen, satisfies the requirement needed for the 2:1 whole number ratio exhibited by the familiar formula, H_2O. Water is not a polymer!

Bob: That's the one I did. *(Pointing at the drawing in number 9 of Figure 1.)*

Me: Really?

I stared in disbelief. That one was so outrageous. The professor had saved it for last and jokingly called it "poly-water." I thought, how could Bob have come from my chemistry class in high school with a mental image of water so far from the truth? I was dismayed.

Me: Why did you draw it that way?

My brain rationalized that Bob had had several years of high school and college between my class and now. Maybe someone else had warped the concept I had hoped would remain. Surely, I didn't place that image in his mind. Surely, it had nothing to do with my competence as a teacher!

Bob: I guess because it was the last day to party. It wasn't going to count anyway. I just got creative!

He smiled broadly with no remorse.

I returned Bob's smile with the knowledge that my investment of time away from my classroom would be even more valuable than I had hoped. I knew I was going to learn much more than biochemistry that term.

If we really want to improve America's teachers, we need to give them learning opportunities just as meaningful as my experience with Bob. Not every teacher can be paired with a former student, but we need to find ways to give practicing teachers the chance to reflect on the impact of their teaching, update their own content knowledge, and re-establish why they value lifelong learning.

So, where does "poly-water" come from?

The Atlas of Science Literacy (2001) provides strand maps that begin in kindergarten and continue over the school years with a series of connected benchmarks leading to an understanding of atoms and molecules. The *Atlas* notes, "Water provides an especially important example...because it is familiar and accessible to students.... There is some evidence that carefully designed instruction carried out over a long period of time may help...students develop correct ideas about particles."

Clearly, Bob's science education did not include a series of connected benchmarks. The "long period of time" from a tenth-grade chemistry class to graduate school did not reinforce what I hoped Bob would remember from my teaching. When pressed, Bob allowed his carefree imagination to fill in the gaps.

As my lab partner, Bob finally learned about hydrogen bonding in water molecules—and quite a bit more. And I became painfully aware of how his preparation affected my lab grade. That is what I call authentic accountability!

Deanna Buckley is a field coordinator in the Delta Rural Systemic Initiative at the Center for Science and Mathematics Education at the University of Southern Mississippi. Her duties include researching and demonstrating best practices in K-12 science and mathematics instruction for school districts that have signed an agreement to make systemic change. She taught science for 17 years at Picayune Memorial High School in Picayune, Mississippi. Email: deanna.buckley@usm.edu

Reference

American Association for the Advancement of Science and National Science Teachers Association. *Atlas of Science Literacy.* (2001). Washington, DC: Authors.

More About the Delta Rural Systemic Initiative

Students in rural areas, particularly those areas characterized by persistent poverty, typically receive much less instruction in science and mathematics than do students in suburban or advantaged urban classrooms. Moreover, societal conditions add to the barriers that keep these students from achieving. Taken together, these circumstances negatively affect a child's chances of going to college or pursuing a career that could provide a better quality of life.

The Delta Rural Systemic Initiative is addressing the situation by using data-driven decision making, analyzing curriculum, providing professional development, promoting convergence of resources, supporting community engagement, and analyzing statewide and district policies. Its mission is to bring about systemic reform in science, mathematics, and technology teaching in the rural communities of the Delta regions.

The Delta Rural Systemic Initiative serves rural districts in Mississippi, Arkansas, and Louisiana. For more information, visit the web site (www.drsi.org).

Turning Misconceptions into Teachable Moments

Having misconceptions is part of the human condition—and teachers are only human. Knowing you can't be right all the time, what can you do?

by Jennifer Gonya, ENC Instructional Resources

Does this sound familiar? You have explained a concept and you're rather pleased with your clarity until students try to put it in their own words. They are not even close to what you said. You wonder how this is possible if they were paying attention? Even worse, students may say nothing, believing that they have understood, and not reveal their misconceptions.

When I was in middle school I understood my teacher to say, "Astronauts float in space because they are weightless." Later I learned that weight had to do with gravity so I deduced that astronauts must have no gravity acting on them if they are weightless. It made sense to me. I always kept putting the term "weightless" on the test sheets and I kept getting the answer right.

No one ever questioned my understanding until a high school teacher asked me, "If there is no gravity in space, what holds the moon in its orbit?" Oops, I never thought of that. Science tells us that astronauts and the moon are actually falling toward the earth.

That high school experience made me realize that teachers could use misconceptions as a teaching tool. Later, when I became a high school physics teacher, I would ask my classes why astronauts could float in their spaceships. Inevitably, most students would use the term "weightless." When I asked for clarification, they would say that there is no gravity in space. By starting with this misconception, we were on our way to learning.

Teachers Have Misconceptions, Too

In a classroom where students are passive learners, a teacher's statements go unchallenged. Then, through a student's question, a conversation with other teachers, or news from a reputable piece of research, a truth that the teacher has held for a very long time is revealed as a misconception. This uncomfortable place can be a good thing when teachers are willing to reflect on their understanding. As educators we must be aware that science is ever-changing, and we cannot expect ourselves to know everything.

This notion is described in the book *The Hundred Languages of Children* (Edwards et al., 1998), which discusses the Reggio Emilia approach to early childhood education. Teachers at these schools envision education as a never-ending project, a metamorphosis of people, resources, and research that continually transforms to accommodate present conditions. The founder of the school, Loris Malaguzzi, notes:

> It is important for pedagogy not to be the prisoner of too much certainty, but instead to be aware of both the relativity of its powers and the difficulties of translating its ideals into practice. (p. 58)

If, as science teachers, we challenge students to think like scientists and act like scientists, why don't we challenge ourselves in this same way? Don't scientists continually seek information and clarification of their understandings?

Students probably learn something new about science in their classes every day, but do teachers? If we truly believe in lifelong learning, we must know that a teacher is always in the making. Modeling that belief in our classrooms allows avenues for productive dialogue, critical thinking, and problem solving. Isn't that what we want for our students?

Jennifer Gonya is the senior science abstractor in ENC Instructional Resources. Formerly a high school physics and chemistry teacher, she is now completing her doctorate in cognitive science. Email: jgonya@enc.org

Reference

Edwards, Carolyn P., Gandini, Lella & Forman, George E. (1998). *The Hundred Languages of Children: The Reggio Emilia Approach—Advanced Reflections.* 2nd ed. Greenwich, CT: Ablex.

DISCUSS

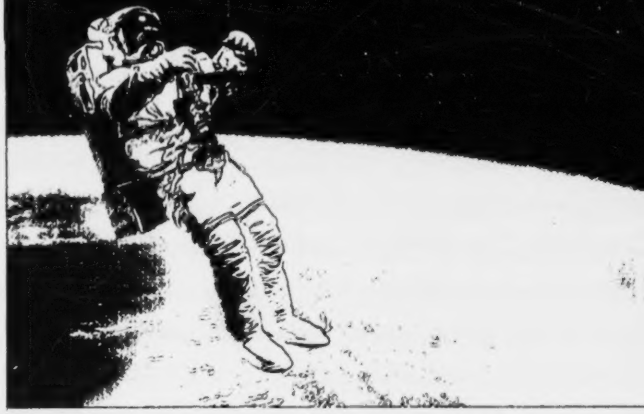
ENC is hosting an online discussion of this article. Join other educators talking about questions such as these:

Do you have an effective way of recognizing and "teaching to" students' misconceptions about science or mathematics?

How did you clear up a misconception you held?

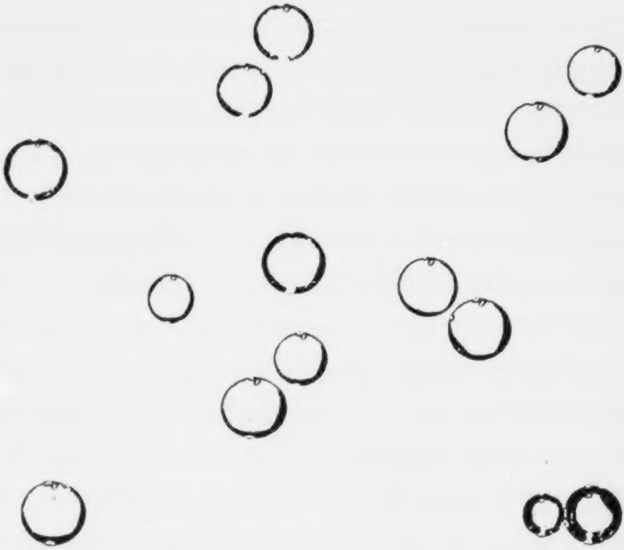
Visit enc.org/focus/content/discuss

Teachable Science Misconceptions



Only two of the following statements are correct based on our current scientific understanding. The rest are common science misconceptions. Can you tell the difference?

1. You can stand a raw egg on end only on the day of the vernal (spring) equinox.
   www.badastronomy.com/bad/misc/egg_spin.html
2. Water spins down a drain one way in the Northern hemisphere and the other way in the Southern hemisphere.
   www.badastronomy.com/bad/misc/coriolis.html
3. Oil molecules are not attracted to water.
   www.princeton.edu/~lehmann/BadChemistry.html#hydrophobic
4. Raindrops are tear-shaped.
   www.ems.psu.edu/~fraser/Bad/BadRain.html
5. The greenhouse effect and global warming are the same thing.
   www.ems.psu.edu/~fraser/Bad/BadGreenhouse.html
6. The seasons are caused by the change in the distance of the Earth to the Sun.
   www.badastronomy.com/bad/misc/seasons.html
7. Hot water freezes faster than cold water.
   math.ucr.edu/home/baez/physics/General/hot_water.html
8. Electricity is a type of energy.
   www.amasci.com/miscon/energ1.html
9. Glass is a liquid.
   math.ucr.edu/home/baez/physics/General/Glass/glass.html
10. The speed of light is not constant.
    math.ucr.edu/home/baez/physics/Relativity/SpeedOfLight/speed_of_light.html



Items 1-6 come from Bad Science (www.ems.psu.edu/~fraser/BadScience.html) College of Earth and Mineral Sciences, Pennsylvania State University, 1995. ENC-004086.

Items 7-10 come from Science Hobbyist (www.eskimo.com/~billb), Eskimo North, Inc., 1998. ENC-012431.

Answer: Items 7 and 10 can be correct.

Aspiring to Be a Teacher

A college-age mathematician describes the teacher who inspired him—and his dreams of teaching in the future.

by Judy Spicer, ENC Instructional Resources, and Michael Khoury, Jr., Dension University, Granville, Ohio,

When I learned that a local college student, Michael Khoury, had earned honorable mention in the prestigious William Lowell Putnam Mathematical Competition, I contacted him to get his perspective on mathematics teaching and learning. I suspected that teachers with a good understanding of mathematics had influenced him. My hunch proved correct. His respect and appreciation for teachers and the teaching profession will hearten *ENC Focus* readers.

Do you have any memories from your experiences in the mathematics classroom that made you interested in mathematics or mathematics contests?

My interest in mathematics began earlier than I can remember or trace, and I have been lucky to have many good teachers. However, there is one who stands out above the rest. Mrs. Sandy Fox was my math and science teacher at East Hills Middle School in Bloomfield Hills, Michigan. She was the coach of MathCounts, a competition for middle school students.

Mrs. Fox was an excellent teacher who prepared her own textbook (textbinder) and always required students to understand what they were doing and why. When she discovered my interest in mathematics, she talked to me outside of class. Then, she devised a special system in which I would study books such as *The Art of Problem Solving* (which I recommend highly) instead of coming to math class.

We would meet in the mornings, before school, several times a week and talk about what I had been reading and try to push to the next level. As I look back, the amount of special time and effort Mrs. Fox put into helping me was really amazing. When I went to high school, she gave me a long list of competitions that I should be sure to try.

Tell me more about your experiences in math contests.

I participated in every competition I could in high school, even Canadian competitions where I competed just for practice. One year, I won the Canadian "Cayley" competition with a perfect score but took honorable mention because I was not Canadian. For four years, I participated in the Michigan Math Prize competition, taking first place my junior year and second place my senior year.

This allowed me to participate in the Atlantic Regions Mathematics League (ARML) competition, which sends large groups of math students to regional meets to compete in teams of 15. This is an outstanding competition because it has so many parts that rely on cooperative problem solving and teamwork, and also because it draws together similarly inclined students who might not otherwise have met.

I also had some success in the American Mathematics Competitions (AMC) events, the Annual High School Mathematics Examination (AHSME), and the American Invitational Mathematics Examination (AIME), on which I earned a high enough score to participate in the USA Math Olympiad. This is a six-problem, six-hour test, similar in difficulty and format to the Putnam (see box on next page). Though I never earned a spot on the International Olympiad team, I had the amazing experience of attending the Math Olympiad Summer Program (MOSP) in Lincoln, Nebraska, in which the top two dozen students in the country are given advanced training. Again, a combination of stellar lecturers and the opportunity to form relationships with "the best of the best" made the two summers I spent in Nebraska among the most memorable of my life.

How did these experiences influence your college work?

My experiences at the math contests helped me to develop many interests in the field of mathematics. My interest in logic led to an article, "Smullyan's Vizier Problem," published in the December 2001 issue of *Math Magazine*. I have submitted "Algebraic Integers—A Contradiction in Terms?" to *Communications in Algebra*, and I wrote but have not yet submitted a paper on infinite series. My honors thesis will be on quantum information theory. I find graph theory, number theory, and analysis generally fascinating. I am also interested in foundations of mathematics and am trying to understand how mathematicians think and how they communicate that thinking.

What are your plans for the future?

I cannot remember a time when I was not tutoring in some form, and I do not envision a time in my future when I will not be teaching at some level. Currently, I am trying to decide whether I want to be a high school math teacher or college professor. I am enjoying my education classes very much, and I am very impressed with the rigor of the program. I have heard horror stories of education programs being fluffy and pointless, but that has not been my experience.

People tell me that I belong in a university—I've actually been told that I'm "too good a teacher for high school." I don't think that way at all. I believe K-12 education makes all the difference. And I do not think I am naive in saying that teaching is an admirable, noble, respectable profession.

Whether I choose high school or college teaching, I know that I will spend my life trying to influence the next generation as positively as my teachers have influenced me.

Michael Khoury, Jr., is a senior at Denison University in Granville, Ohio. He has a double major in mathematics and education and a minor in Spanish. He attended elementary and middle school in the Bloomfield Hills School District in Oakland County, Michigan. He graduated from Brother Rice, a Christian Brothers high school in Bloomfield Hills.

Reference

Lehoczky, Sandor & Rusczyk, Richard. (1996). *The Art of Problem Solving*. New York: Greater Testing Concepts.

Mathematics Competitions—Everybody Wins!

Michael Khoury (see accompanying essay) received an honorable mention in the 2000 William Lowell Putnam Mathematical Competition, an annual event administered by Mathematical Association of America.

First offered in 1938, the competition is designed to test originality and technical competence on theories and topics found in undergraduate mathematics. Questions involve elementary concepts from group theory, set theory, graph theory, lattice theory, number theory, and cardinal arithmetic.

The competition's founder, William Lowell Putnam, aimed to promote a healthful rivalry in mathematical studies among the colleges and universities of the United States and Canada. For more information visit the Putnam web site (math.scu.edu/Putnam).

For information about mathematics competitions for K-12 students, visit ENC's Classroom Calendar (enc.org/thisweek/calendar) and go to the June 3, 2002, entry, Mathematics Competitions—Not Just for Geniuses! Or see the following web sites:

American Mathematics Competitions (AMC)
www.unl.edu/amc/index.html

Atlantic Regions Mathematics League (ARML)
www.arml.com/Dotorg/

Canadian Mathematics Competitions
cemc.uwaterloo.ca/

International Mathematical Olympiad (IMO)
imo.math.ca/

Math Competitions on the Web
donut.math.toronto.edu/~naoki/comp.html

Math Counts
www.mathcounts.org

The Mandelbrot Competition
www.mandelbrot.org/

The Math League
www.mathleague.com/

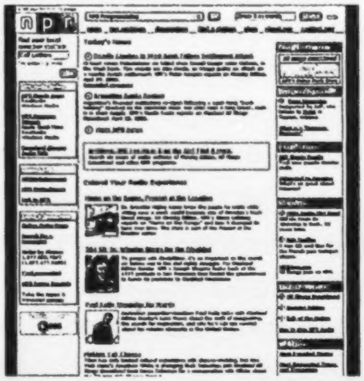
Ole Miss Problems of the Week
www.olemiss.edu/mathed/problem.htm

Did You Hear About . . .? What Does It Mean . . .?

Here are some easy-to-access sources that can help you stay aware of scientific discoveries of interest to your students.

by Susan Dahl, Fermi National Accelerator Laboratory, Batavia, Illinois

How many times has a youngster come to you excited about a report of a new dinosaur fossil or concerned about a recent warning of climate changes that seems to contradict what she has learned in science class? How do you keep up to date on new scientific breakthroughs that your students hear about almost daily in the media? Those discoveries become our students' realities as research filters into goods and services that impact our lives.



When students come to class with questions, we don't need to have all of the answers, but we should be motivated to keep abreast as educators. We can inquire along with our students and apply the methods used in science to keep current.

Making use of television, radio, the Internet, and journals and other print resources, we all have the latest scientific information readily available. It does not have to be complicated to stay current! Here are just a few examples of free or inexpensive resources.

Well-respected sources of weekly information include the Science Times section, which appears on Tuesdays in *The New York Times*, and the weekly newsmagazine *Science News*. Before the age of the Internet, these publications were expensive, but now the material is available online. (See reference list for web addresses.) Some features include teacher guides and curriculum resources to connect the content to the classroom.

A weekly source of science news in another medium is National Public Radio's Talk of the Nation: Science Friday broadcast. If you miss the program, check out NPR's web site, which includes audio files.

ENC provides an excellent source of daily science information, selected especially for K-12 teachers, in the Education Headlines section of ENC Online. See the sidebar on the next page for more information and for details on how you can receive this service via email.

Another way to stay up to date is through colleagues who have common interests and want to share their perspectives on what they hear, see, and read. Fellow teachers in your school are an excellent source, and national organizations, such as the National Science Teachers Association, are another good place to network.

For both national and local connections, check out the National Network of Eisenhower Consortia and Clearinghouse (see contact information on pages 12-13). For example, teachers living near the Fermi National Accelerator Laboratory in Batavia, Illinois, can find a rich, browsable collection of up-to-date, quality materials for mathematics, science, and technology in the Teacher Resource Center of the North Central Mathematics and Science Consortium.

Students love television. The Public Broadcasting Service and the Discovery Channel provide accurate and appealing reports on science and technology, but some television shows present slanted or incorrect information. Taking class time to discuss such programs is an excellent way to encourage students to think critically.

Many print magazines and journals remain an important source of information about scientific discoveries. I highly recommend *Discover* magazine's special January 2002 issue featuring the Year in Science. Like many other print periodicals, *Discover* is also available online. Standard journal index tools such as *General Science Index* or *Readers' Guide to Periodic Literature* can be helpful in locating the latest information organized by topic.

As much as I love books, I have to admit they have the disadvantage of sometimes being out of date before they appear in bookstores and libraries. Almanacs that are updated annually are a good source of the latest informa-

DISCUSS

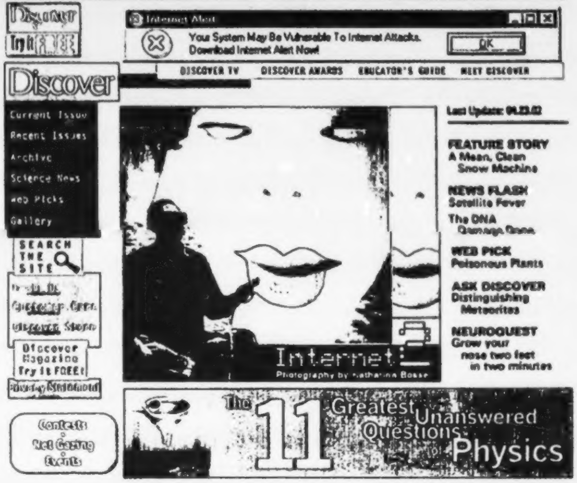
ENC is hosting an online discussion of this article. Join other educators talking about questions such as these:

What are your favorite sources of math or science information? Why do you like them?

What kinds of news and updates would be most helpful for you to find online?

Visit enc.org/focus/content/discuss

tion. One of my current favorites is *Time Almanac 2002 with Information Please.* The web site of the National Science Teachers Association provides a searchable section of recommended resources. The information includes science teachers' reviews of new books. Another good way to keep up on the availability of new books is by checking the major online bookstores, Amazon or Barnes and Noble.



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A Mean, Clean Snow Machine
NEWS FLASH
Satellite Fever
The DNA Damage Gene
WEB PICK
Poisonous Plants
ASK DISCOVER
Distinguishing Meteorites
NEUROQUEST
Grow your nose two feet in two minutes
Internet
Photography by Katharina Bosse
The 11 Greatest Unanswered Questions of Physics

Susan Dahl is education specialist at the Lederman Science Education Center of Fermi National Accelerator Laboratory, Batavia, Illinois. She established the Fermilab Teacher Resource Center collection and serves as the ENC Demonstration Site Coordinator for the North Central Mathematics and Science Consortium. The Teacher Resource Center contributes to the Educational Software Preview Guide *and the Association for Supervision and Curriculum Development's* Only the Best *educational software directories. Email: sdahl@fnal.gov*

References

Amazon.com, www.amazon.com

Barnes & Noble, www.barnesandnoble.com

Brunner, Borgna (Ed.). (2002). *Time Almanac 2002 with Information Please.* Boston, MA: Information Please.

Discover, www.discover.com

Flatow, Ira, host, Talk of the Nation: Science Friday, National Public Radio, New York, NY. (Check local listings for times.) www.sciencefriday.com or www.npr.org/programs/scifri

National Science Teachers Association, www.nsta.org

New York Times, www.nytimes.com/pages/science/index.html

Science News, Washington, DC: Science Service, www.sciencenews.org

Daily News Updates for Mathematics and Science Teachers

Daily science news updates are a regular feature of the ENC Online service Education Headlines. Monday through Friday, ENC staffers search the pages of more than 50 newspapers and specialized science sites for links to articles about science. The articles appear under the subhead "Math, Science and Technology in the News."

On any given weekday, math and science teachers will find headlines such as these,

- "The Science of Speed"—from a *Newsweek* magazine article
- "New Species Clarifies Bird-Dinosaur Link" —*Science Daily* story based on a Field Museum press release,
- "Storm trackers: Missions over Pacific help meteorologists predict weather"—an Associated Press article
- "Roiling dust cloud filled USGS scientists with a sense of urgency"—from the *St. Louis Post-Dispatch*, February 10, 2002.
- "In the Shadow of Extinction"—from the *New York Times*, February 8.

Follow the link from Education Headlines and the full articles are available for your personal learning or for enriching classroom discussions and assignments.

Another subhead of the daily Education Headlines that is of particular interest to math and science teachers is called "K-12 Math, Science, Technology Issues and Practices." It contains articles about science projects undertaken in classrooms, novel uses of computer technology in school settings, exceptional mathematics students, and more.

Other sections of the Headlines site are devoted to articles about school administration, funding, politics and education, school and student performance, the teaching profession, and social issues.

You can register to receive Education Headlines, Monday through Friday, year round by email. Go to www.enc.org/register. Or you can check the headlines daily by going to ENC Online (www.enc.org) and clicking on News, then Education Headlines. A half dozen or so headlines are often featured on the front page with links to the full offerings for the day.

Focus on the Collection

This section presents highlights from the full ENC record for exemplary resources selected to illustrate this issue's theme.

ENC's Collection and Catalog

ENC's collection of mathematics and science resources is the most comprehensive in the nation. 20,000 resources are housed in our national repository, with new items arriving daily. We collect materials from federal and state agencies, commercial publishers, professional organizations, school districts, and individuals. The collection includes print materials, software and CD-ROMs, kits and manipulatives, along with hundreds of excellent Internet sites.

All materials are cataloged by ENC, and the catalog records are searchable from our web site (enc.org). Part of each catalog record is a detailed description of the resource written by ENC experts in mathematics and science education. These descriptions are not evaluative reviews, but the online record does include references to reviews, awards, and other evaluative materials.

A Continuous Process of Growth

by Carol Damian and Terese Herrera, ENC Instructional Resources

"Being a teacher implies a dynamic and continuous process of growth that spans a career." (NCTM, 1991, p. 125)

Teaching any subject requires continual growth in several areas: understanding students and how to engage them, knowledge of the subject content, and skill in teaching that content to those students. The selection of resources for this *Focus* Collection Section targets one of these areas — teachers' content knowledge.

In preparing this list, we first asked ourselves: Why would you, practicing and preservice teachers or professional developers, feel the need to improve your knowledge of mathematics and science? Perhaps a student's question challenged you, or your own asking "Why?" moved you to look deeper into the subject matter. Perhaps you've been assigned to teach a different grade level or subject. Certainly, through your own experience you know how strongly content knowledge affects what we teach and how we teach it.

ENC graphic: Jisun An

This last is particularly evident in inquiry teaching. To guide students as they explore new concepts, we teachers need to know the terrain well, for we are apt to hold students within the borders of territory we know well ourselves. If students are to know the breadth and depth of the "big ideas" of math and science, teachers need to know these ideas even better. Otherwise, we may unknowingly concentrate on the details of a topic without helping our students to understand how the details fit into the larger picture.

A second question we asked was: How can educators go about improving their conceptual understanding of the subjects they teach? We landed on these possible answers:

- Study groups, most profitably organized by subject and grade level, offer a way to share ideas and reflections.
- Independent learning, an alternate choice, can be embedded in preparation for teaching a topic.
- Formal workshops and courses, face-to-face or online, are another resource.

The materials featured here can be used in any of these settings.

As we searched for the materials for this issue, we generally selected topics that make up the core K-12 curriculum. An exception was the inclusion of cutting-edge topics, such as chaos and fractals, which may not have entered many math and science classrooms but about which you may want to learn more.

The resources in this section are not necessarily traditional teacher materials; some are actually directed to students but are prepared well, and thus enrich teachers' knowledge as well. You will even find here:

- textbooks with exceptionally in-depth accompanying materials,
- information books and web sites dedicated not to pedagogy but strictly to math and science content, and
- general sources of information on current, breaking topics as well as more traditional school subjects.

We are aware of the time and scheduling constraints that make professional development a challenge for teachers. We hope this selection of resources offers you efficient access to materials that will assist you in your efforts to gain a deeper understanding of the science and mathematics in the curriculum you teach—or that you are helping others to teach.

There are more than 20,000 mathematics and science education resources in the total ENC collection. From all of these, we could select only a few exemplary ones for this *Focus* topic, Increasing your Content Knowledge in Mathematics and Science. There are many more that are worthy of your consideration. You can jump online at enc.org, and search the Curriculum Resources section to learn more. A few examples of search words that you might use are *probability, algebra, chemistry, integrated science*, or *numbers* and *operations*. Selecting your grade level could help narrow your search results to a more manageable number of items. We hope these resources help you continue to enrich your content knowledge—and that you enjoy the exciting professional journey.

Carol Damian is ENC's science education specialist (email: cdamian@enc.org), and Terese Herrera is ENC's mathematics education specialist (email: therrera@enc.org).

Reference

National Council of Teachers of Mathematics. (1991). *Professional Standards for Teaching Mathematics.* Reston, VA: Author.

Featured Resources

Increasing Your Mathematics and Science Content Knowledge

Algebra and Algebraic Thinking

56 Algebra in Simplest Terms
56 NavigatingThrough Algebra in Prekindergarten-Grade 2
56 Optimality Pays
56 Thinking with Mathematical Models
57 Vector

Calculus

57 The Hitchhiker's Guide to Calculus
57 Mathematics!
58 Problems for Student Investigation
58 Rates of Change
58 Readings for Calculus

Geometry

58 Dave's Short Trig Course
59 Euclid's Window
59 The Joy of Pi
59 Mathematics of Cartography
59 Shape and Space in Geometry
60 The Theorem of Pythagoras
60 Totally Tessellated
60 Visual Solid Geometry

Number and Operations

61 The Fibonacci Numbers and the Golden Section
61 Fourth Grade Everyday Mathematics Teacher's Resource Package
61 Math at Hand
62 Math Matters, Grades K-6
62 Mathematics for Elementary Teachers via Problem Solving
62 A Mathematics Source Book for Elementary and Middle School Teachers
62 The Missing Link
63 Number and Operations, Part 2: Making Meaning for Operations

63 Primary Mathematics
63 Reconceptualizing Mathematics
64 Teaching Fractions and Ratios for Understanding
64 The Universal History of Numbers

Data Analysis and Probability

64 The Cartoon Guide to Statistics
64 Exploring Data
65 Exploring Projects
65 Exploring Surveys and Information from Samples
65 Insights into Data
66 A Mathematician Reads the Newspaper
66 Seeing Statistics
66 Statistics

Math on the Cutting Edge

66 Chaos
67 Fantastic Fractals Online!
67 Fractals
67 In Code
67 Life by the Numbers
68 Mathematics
68 MegaMath

For Further Exploration in Mathematics

68 Knowing and Teaching Elementary Mathematics
69 The Math Forum Internet Mathematics Library
69 Math: Facing an American Phobia
69 MATRIX
69 Why Do Buses Come in Threes?

Chemical Science and Chemistry

70 ABCs of Chemistry
70 Chem4Kids!
70 Chemistry
70 Chemistry Experiments You Can Do at Home
71 Chemistry Lessons
71 Chemistry: Atoms and Elements
71 Exploring the Way Life Works
71 Fundamentals of General, Organic and Biological Chemistry
72 The Home and School Science Activity Book: Matter
72 WebElements: Scholar Edition

Earth, Space, and Environmental Science

72 All About Water Ecosystems
73 The Changing Earth
73 Climate and Seasons
73 Earth
73 Energy Resources
73 Environmental Science
74 NOVA: Hot Science
74 Only One Ocean: Grades 5-8
74 Planet Earth
74 Sunflower/Girasol Air Unit
75 SpaceKids
75 Star Factories
75 Understanding Your Environment
75 Waste in Place
76 WISE, the Web-Based Inquiry Science Environment

Life Science and Biology

76 Biology Lessons
76 Evolution
76 From Bacteria to Plants
77 Great Feuds in Medicine
77 Hidden Worlds
77 Human Biology
77 Learning Programs for Biology
78 Patterns of Nature
78 Plants and Animals
78 A Portfolio of Teaching Ideas for High School Biology
78 The Structures of Life

Physics

79 All About Simple Machines
79 Changes in Properties of Matter
79 Far Out physics
79 Holt Science Spectrum: A Physical Approach
80 The Home and School Science Activity Book: Physical Science
80 Physical Science

80 Physics Education
81 Physics in Context
81 Physics Matters!
81 Physics, the Human Adventure
81 Shedding Light on Science
82 Transfer of Energy
82 Take a Technowalk to Learn About Materials and Structures

Integrating the Sciences

82 EIA Kids Page
83 Global Lab: Unit 4
83 Natural Inquirer
83 Science
83 Science 3
84 SciencePlus: Level Blue
84 Young Investigators

For Further Exploration in Science

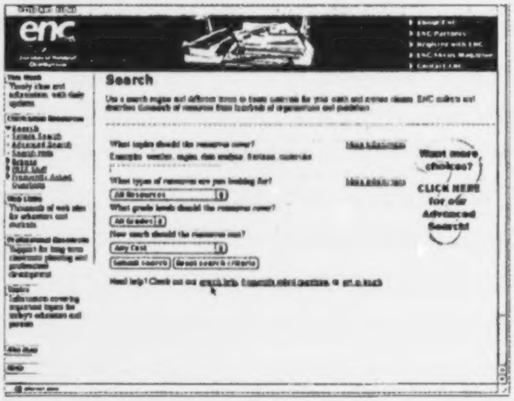
84 Ask the Experts
85 Case Studies in Science
85 Inquiring into Inquiry: Learning and Teaching in Science
85 Leveraging Learning
85 Nibbling on Einstein's Brain
86 Practicing Science
86 Pursuing Excellence
86 Science as Inquiry in Action
86 Why?

Searching the ENC Collection of Resources

The resource descriptions printed in this magazine are abbreviated versions of the full catalog records available online. You can access ENC's vast collection of curriculum resources by visiting ENC Online (enc.org).

To find the online record for resources featured in *ENC Focus*:

The easiest way to browse the online records of resources featured in an issue of *ENC Focus* is to go to our web site (enc.org) and select the link in the top right corner to ENC Focus Magazine. Select the title of the appropriate issue, then scroll down to the Focus on the Collection section. Finally, follow the links to the records of your choice.



To find other resources:

When you visit ENC Online (enc.org), the Curriculum Resources section in the left navigation bar offers both a simple and an advanced search with help features for each. The advanced search allows you to choose particular subject words, grade level, cost, and type of material to find exactly what you need.

JUMP ONLINE!

For example, materials for this magazine were found through the use of subjects such as algebra, chemistry, or fractals. For professional developers looking for workshop materials, add the Resource Type "professional development."

Also in the Curriculum Resources section is the Browse option. Find the subject you are interested in. Once a first page of results is returned, you can use the "Customize using advanced search" feature to further limit your search.

Additional assistance is available online (enc.org/resources/search/help) or by contacting the ENC Information Services staff by email (library@enc.org) or phone (614) 292-9734.

Algebra and Algebraic Thinking

Algebra in Simplest Terms

Series: Annenberg/CPB Collection
Grade 8 and up
1991
Contributor(s): David I. Schneider, John Hornsby, Margaret L. Lial, and Peter A. Lindstrom

COLLEGE ALGEBRA

The 26 lessons on these videos, accompanied by study guides and a related textbook, were designed to prepare college students for further study of trigonometry, calculus, or statistics. They are also helpful at the high school level, or in teacher professional development, as a review of algebra subject matter or as enrichment of algebra with real-world applications. Graphic illustrations of the mathematics and on-location examples help viewers connect mathematics to everyday life. Some examples of on-site illustrations include the quality control in potato manufacturing, the science of fire-fighting, and the development of fireworks. Mathematician Sol Garfunkle introduces real-world problems and demonstrates the value of algebra for problem solving. Sample problems include estimating the bass population of a lake and determining traveling distances in hang gliding. In each video lesson, the host first outlines the subject matter and highlights the relevant algebraic techniques with step-by-step, animated examples of the procedure. Symbols, charts, pictures, and computer graphics illustrate algebraic techniques ranging from solving simple equations to solving systems of linear inequalities and evaluating sequences and series. (Author/JRS) ENC-021155

Ordering Information
Annenberg/CPB, PO Box 2345, South Burlington, VT 05407
(802) 862-8881 / Fax: (802) 846-1850 / Toll-free: (800) 532-7637
www.learner.org
$106.95 per text (hardbound)
$50.00 per study guide (paperback)
$20.00 per teacher's guide (spiral-bound)
$199 per set of 7 videos

Navigating Through Algebra in Prekindergarten-Grade 2

Series: Navigations
Grades PreK-2
2001
Contributor(s): Carol R. Findell, Carole E. Greenes, Linda Schulman Dacey, Marian Small, and Mary Cavanagh

Part of the Navigations series, this book and accompanying CD-ROM are designed to help teachers introduce fundamental algebraic concepts. The series extends the NCTM's *Principles and Standards for School Mathematics* into classroom practice. The first four books in the series address the Algebra Standard, with one book for each grade band. Each book contains background information about the development of algebraic reasoning and complete lesson plans with activities to engage, explore, and extend algebraic concepts. Each lesson plan states goals for student accomplishment and suggests questions to stimulate thinking about mathematics. The accompanying CDs contain grade-band-specific professional development readings and applets for interactive student exploration. This book offers lessons focusing on repeating and growing patterns, introducing the concepts of a variable and equality, and examining relations and functions. In a sample activity, students solve missing-addend problems involving distances drawn to scale on maps. The goal is for students to write number sentences to represent unknown distances using triangles and squares as variables. In whole-class activities, students work with the teacher to estimate distances on a U.S. map, determine distances, and write number sentences for a simple line segment map. The accompanying CD offers two applets: one for exploring equality with an interactive pan balance and the other for creating and extending patterns with geometric shapes and colors. (Author/JRS) ENC-019419

Ordering Information
National Council of Teachers of Mathematics, Inc., 1906 Association Drive, Reston, VA 20191
(703) 620-9840 / Fax: (703) 476-2970 / Toll-free: (800) 235-7566
www.nctm.org
$24.95 per book and CD-ROM (Macintosh/Windows)

Optimality Pays

Series: HistoMAP
Grades 9-12
1992
Contributor(s): Jeganathan Sriskandarajah

Designed for high school students, this series provides a set of student-ready modules that apply mathematics within a historical framework. Within each module are lesson plans, teaching strategies, worksheet masters with answers, sample tests, and transparency masters. This module focuses on finding the best way to do processes such as maximizing profit or minimizing costs. The module demonstrates how mathematics provides tools for government and business leaders to use when dealing with issues such as blending gasolines, arranging crews for airplanes, and structuring medical procedures for optimal efficiency. The mathematical tools involved in these studies are rooted in geometry and algebra. They are based on graphing lines and solving linear systems of equations simultaneously. Exercises and answers are included. (Author/LDR) ENC-007522

Ordering Information
Consortium for Mathematics and Its Applications, Suite 210, 57 Bedford Street, Lexington, MA 02173
Fax: (781) 863-1202 / Toll-free: (800) 772-6627
www.comap.com
$11.99 per book

Thinking with Mathematical Models

Series: Connected Mathematics
Grade 8
1998
Contributor(s): Elizabeth Difanis Phillips, Glenda Lappan, James T. Fey, Susan N. Friel, and William M. Fitzgerald
Publisher: Dale Seymour Publications

Part of the Connected Mathematics Project (CMP) series, this student text and teacher's guide focus on constructing mathematical models, both algebraic and graphic. The series is a complete middle school mathematics curriculum that

emphasizes connections among the core ideas of mathematics, between mathematics and other subjects, among classroom activities and student interests, and to real-world applications. Each unit contains investigations supporting problem-centered teaching and breaks instruction into three phases: launch, explore, and summarize. This instructional model is intended to encourage higher-level thinking and problem solving, and to help make better sense of mathematics and its uses. In this unit, students use data from experiments with paper bridges and teeter-totters to represent trends in data. In one investigation, for example, students read a story about a bus trip gone awry and analyze graphs representing different aspects of the trip. They also create stories that interpret events modeled graphically. In a mathematical reflection for the unit, students look at relationships associated with real-life situations that can be represented by graph and equation models. The teacher's guide explains the mathematics a teacher needs to understand in order to teach the unit. Also included are lesson plans, blackline masters, and suggestions for using embedded assessment, journals, portfolios, and testing materials. The CMP curriculum is compatible with the criteria for teaching and learning mathematics described by the NCTM *Professional Standards for Teaching Mathematics* and in the 1989 NCTM curriculum standards. (Author/JRS) ENC-011888

Ordering Information
Scott Foresman Addison Wesley, PO Box 2500, Lebanon, IN 46052
Fax: (800) 841-8939 / Toll-free: (800) 554-4411
www.scottforesman.com
$19.97 per teacher's guide
$5.97 per student book

Vector

www.ies.co.jp/math/java/vector/index.html
Series: Manipula Math Collections
Grades 9-12
2001
Contributor(s): Ichiro Kobayashi, Katsuhiko Sato, Kazuhiro Fukushima, and Shigeru Tsuyuki
Publisher: International Education Software (IES) Inc.

Visitors to this web site are invited to interactively explore vector concepts. The interactive animations or applets each illustrate a vector-related problem, theorem, or relationship. Each applet lets the student do structured exploration and features a dynamic model showing the numerical relationships the vectors represent. Students can manipulate the size and position of vectors and their relationships to investigate topics such as the area of a parallelogram defined by two vectors. Students are able to explore the meaning of dot and line product of vectors, the unit vector, and the circle of Apollonius. (JRS) ENC-020758

Calculus

The Hitchhiker's Guide to Calculus

Grade 11 and up
1995
Contributor(s): Michael Spivak
Publisher: Polished Pebble Press

Written as an overview of calculus for students, this book applies the metaphor of European travel to introduce calculus as a method for calculating change. The author explains that the basic meaning of the term "calculus" is related to small stones used for numeric calculations. The book emphasizes developing understanding of the unique concepts that arise in the study of the calculus of change. Numerous illustrations, equations, and diagrams help develop the calculus concepts. The book begins with a review of lines and slope and then goes on to explore nonlinear functions and trigonometric functions. Additional topics include derivatives, maxima and minima, Rolle's Theorem, and the Mean Value Theorem. The book concludes with a chapter about the integral, the Fundamental Theorem of Calculus, and applications of the integral. (Author/JRS) ENC-019500

Ordering Information
Mathematical Association of America (MAA), PO Box 91112, Washington, DC 20090
(301) 617-7800 / Fax: (301) 206-9789 / Toll-free: (800) 331-1622
www.maa.org
$11.95 per book (paperback)

Mathematics!

Series: Project Mathematics!
Grades 9-12
2000
Contributor(s): Tom M. Apostol
Publisher: Project Mathematics!

Part of the Project Mathematics! series, this video presents an overview of the early history of mathematics. The timeline stretches from 5000 B.C., when calendar-makers calculated the onset of the seasons, up to the events that led to the development of calculus in the 17th century. Topics include how number systems developed in different cultures, how number mysticism (as practiced by the Pythagoreans) led to number theory studies, and how astronomy gave birth to trigonometry. The series uses computer animation to demonstrate mathematics concepts in ways that are difficult or impossible to do in a textbook or at the chalkboard. The videos, with accompanying program guides, can be used to support existing courses in high schools and community colleges. In a sample from this video, students see a visual treatment of the development of the Pythagorean theorem and learn of the shocking discovery of irrational numbers. The existence of irrational numbers was kept secret on penalty of death for those who shared the newfound numbers with anyone outside the Pythagorean Society. The program guide summarizes important points for corresponding sections of the video. Some sections of the guide contain exercises that can be used to strengthen mathematical understanding. These exercises emphasize key ideas, words, and phrases as well as applications. References are provided. (Author/JRS) ENC-018315

Ordering Information
Caltech Bookstore, 1-51 Caltech, Pasadena, CA 91125
Fax: (626) 795-3156 / Toll-free: (800) 514-2665
www.bookstore.caltech.edu
$4.95 per workbook (paperback)
$34.90 per video with workbook

Problems for Student Investigation

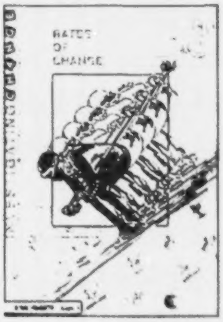
Series: Resources for Calculus
Grade 12 and up
1993
Contributor(s): John R. Ramsay and Michael B. Jackson

The classroom-tested projects in this resource book are designed to help students learn calculus concepts through investigation. The series features materials that address topics and themes of interest to those involved with undergraduate mathematics. This book is one of five volumes that contain supplementary materials for enriching the study of calculus. This volume features 30 projects arranged in five sections: derivatives, antiderivatives and definite integrals, applications of integration, multivariate calculus, and historical projects. The projects require imagination, outside reading, cooperation, and coherent writing. Each one provides a brief statement of the problem for students and more detailed information for instructors, including teaching notes and selected solutions. In the activity "Minimizing the Area Between a Graph and Its Tangent Lines," for example, the problem is: Given a function f defined on [0, 1], for which of its non-vertical tangent lines T is the area between the graphs of f and T minimal? Students are then given further parameters to guide their investigation and instructed to carefully explain the reasoning behind their conclusions. The teacher information includes four examples of possible approaches to the problem as well as a general discussion of the problem and prerequisite skills and knowledge. Suggestions are given for further investigation. (Author/MM) ENC-020287

Ordering Information
Mathematical Association of America, PO Box 91112, Washington, DC 20090
(301) 617-7800 / Fax: (301) 206-9789 / Toll-free: (800) 331-1622
www.maa.org
$38.50 per book (paperback)

Rates of Change

Series: Investigating Change: An Introduction to Calculus for Australian Schools
Grades 10-12
1991
Contributor(s): Mary Barnes
Publisher: Curriculum Corporation



The third unit in the Investigating Change series focuses on the concepts of derivative or rate of change of functions. It begins by establishing the connection between a function's rate of change and the gradient of its graph and then introduces the idea of a gradient function. The unit ends with a lesson on sketching the graphs of gradient functions. The course is designed to motivate students by beginning with real-world problems and gradually developing the mathematics needed to solve them. Its goal is to make calculus accessible through carefully structured investigative activities that help students understand the process of mathematical modeling. To overcome conceptual difficulties often experienced by students in introductory calculus, the text only introduces the idea of limit after carefully developing concepts. This development relies on much graphical representation through the use of computer software or graphing calculators. A central element of this course is student-led discussion in which the teacher takes the role of encourager, provoker, or questioner, but not judge or evaluator. Teacher manuals provide discussion of the goals, pedagogical approach of the course, and assessment ideas, as well as tips and suggestions. (Author/GMM) ENC-008079

Ordering Information
Curriculum Corporation, Victoria, PO Box 177, Carlton South, Victoria 3053 Australia
639-0699 / Fax: 639-1616
www.curriculum.edu.au
$8.95 per teacher's handbook
$6.95 per student book

Readings for Calculus

Series: Resources for Calculus
Grade 12 and up
1993
Contributor(s): Underwood Dudley

This book features a series of essays on the history of calculus and mathematics, as well as the place of mathematics in human knowledge. The 36 essays are arranged into four sections: History, Learning Calculus, Calculus in Society, and About Mathematics. Essay topics include biographical material about such mathematicians as Fermat and Euler, mathematical fallacies, the sociology of mathematics, beauty in mathematics, and applied mathematics. Each essay has a short introduction and contains a set of exercises and problems. (Author/MM) ENC-020288

Ordering Information
Mathematical Association of America (MAA), PO Box 91112, Washington, DC 20090
(301) 617-7800 / Fax: (301) 206-9789 / Toll-free: (800) 331-1622
www.maa.org
$38.50 per book (paperback)

Geometry

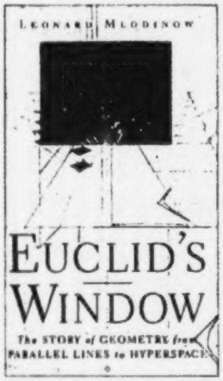
Dave's Short Trig Course

aleph0.clarku.edu/%7Edjoyce/java/trig/index.html
Grades 10-12
1997
Contributor(s): David E. Joyce
Publisher: Department of Mathematics and Computer Science, Clark University

The interactive applets on this web site introduce trigonometry as computational geometry and offers explanations and illustrations of basic trigonometry concepts. The site is designed for students who would like to learn a bit about trigonometry, or brush up on it; it is not offered as a full trig course. Visitors will find applications for trigonometry and hints for successfully studying mathematics. To use this tutorial, students must be familiar with manipulating algebraic expressions and solving equations. Required geometry knowledge includes understanding of similar triangles, the Pythagorean theorem, and other basic concepts. Author David Joyce provides exercises with answers and hints, advocating his belief that such exercises compose the most important aspect of any mathematics course. Students are encouraged to take their time, write ideas down, and draw relevant figures. They are cautioned that the goal of the exercises is not to simply get the answers, but rather to *understand* how to get the answers. As an example, the angle measurement section describes and illustrates the two common ways to measure angles with radians and with degrees. Students investigate the concept through interactive illustrations and 23 related problems. A discussion of digit accuracy is included. (Author/JRS) ENC-018640

Euclid's Window

Grade 11 and up
2001
Contributor(s): Leonard Mlodinow
Publisher: Free Press



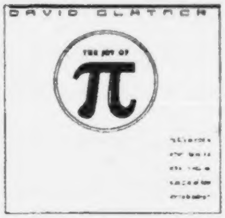
This book traces the story of geometry through the discoveries of five mathematicians: Euclid, Descartes, Gauss, Einstein, and 20th-century Fields Medal winner Edward Witten. It presents the evolution of geometric ideas and mankind's understanding of the universe from Euclid's five postulates to the 20th-century development of string theory and M-theory to explain the fundamental particles of the universe. The text espouses the theory that nature evolves with a hidden order that is revealed through mathematics. Euclid's window on the world, therefore, can be described as two-fold: exact reasoning in mathematics and a way of looking at the world that includes the aesthetic in nature. The book highlights the clashes through the centuries between scientists supporting contending scientific theories and their related mathematics. In the last chapters, the author explores string theory, topology, and the mathematics of higher dimensions. Witten's work on string theory and M-theory are discussed as having an impact on the direction of modern mathematics. (Author/JRS) ENC-021117

Ordering Information
Simon & Schuster Trade, PO Box 218, Paramus, NJ 07563
(212) 698-7000 / Fax: (201) 967-9830 / Toll-free: (888) 866-6631
www.simonandschuster.com
$26.00 per book (hardbound)

The Joy of Pi

Grades 6-12
1997
Contributor(s): David Slatner

Author David Slatner traces the development of knowledge about pi and considers the historical influence of this knowledge. Pi has fascinated generations of mathematicians, ranging from the ancient Egyptians and Archimedes to two modern Russian mathematicians, the Chudnovsky brothers. These modern number theorists have calculated pi to eight million digits with a homemade computer. In this book, sidebars offer pi trivia, cartoons, and limericks. The first one million digits of pi appear throughout the book. A sample chapter, The Circle Square, explores the question: Can a square be constructed, in a finite number of steps, with exactly the same area as a circle using only a straightedge and compass? This is one of the most famous and elusive mathematical puzzles of all times. Pen-and-ink drawings and diagrams illustrate some of the mathematical ideas. References are included. The author maintains a web site with additional information and links to related sites. (Author/JRS) ENC-018556



Ordering Information
Walker Publishers, 435 Hudson Street, New York, NY 10014
(212) 727-8300 / Toll-free: (800) 289-2553
www.walkerbooks.com
$15.95 per book (paperback)

Mathematics of Cartography

math.rice.edu/~lanius/pres/map/
Grades 5-12
1996
Contributor(s): Cynthia M. Lanius
Publisher: Rice University

Students and teachers can use this web site to learn about mapmaking and maps. From the home page, users may access information on the history of mapmaking, which highlights the progression from stick charts and footprints to clay tablets to the use of photographs and computers. The site includes teaching notes, lesson details, and references to online and offline resources. Maps are defined and described in terms of points, lines, area patterns, and colors. Mathematics topics used in mapmaking are discussed, including scale, coordinate systems, and projection. Links are provided to sites that give examples of the concepts described. The site discusses the distortions created by projecting three-dimensional space onto a two-dimensional piece of paper, explaining that different projections are designed to minimize the distortion of particular properties. For example, the Mercator projection angles preserve angles, but distances become progressively more distorted with distance from the equator. A link providing examples of other projections is available. One of four problem-solving questions asks the user to determine the point on the Earth that has the maximum distance (as the crow flies) from the user's home. More than 40 links to other Internet sites are available, providing insights into multiple aspects and applications of mapping, as well as current job listings in cartography and related careers. Winner, ENC Digital Dozen, February 1997. (Author/LDR) ENC-015051

Shape and Space in Geometry

www.learner.org/teacherslab/math/geometry
Series: Annenberg/CPB Project
Grades K-8
1999
Contributor(s): Edward Piou, Gordon Ng, Jeffrey Braxton, Linda W. Braun, M.G Wood, Rick Schmalgemeier, and Tim Erickson
Publisher: Annenberg/CPB Math and Science Project

This online teachers' lab offers interactive activities for teachers to use to explore the geometry of shape and space. The goal of the project is to provide high-quality professional development materials and resources for math and science teachers. At this web site, an introduction outlines the rationale for teaching geometric concepts, briefly describes activities, and explains how these activities correlate with the 1989 NCTM standards. Each activity includes a background page that elaborates on the rationale, provides grade-level information, and connects to the standards for that specific activity. Activities are divided into two broad categories: shape and space. Shape activities focus on identifying properties of various shapes and measuring their dimensions. A sample shape activity begins with observing a 16-block quilt design and reproducing the design electronically. This interactive exploration allows the user to modify the type of symmetry at any time and to redo the activity with a new design. Space activities investigate objects in space, use plot plans to define three-dimensional shapes, and visualize what shadows will be created from a rotated solid. (Author/JRS) ENC-016445

The Theorem of Pythagoras

Series: Project Mathematics!
Grade 9 and up
1988
Contributor(s): Benedict Freedman, James F. Blinn, Sylvie Rueff, and Tom M. Apostol
Publisher: California Institute of Technology

This module is part of a series of computer-animated videos and accompanying workbooks designed to teach basic concepts in mathematics. The modules can be used as support material for existing courses in high school and community college classrooms. The program begins with a brief review of prerequisites that contains excerpts from earlier modules. The video then shows three real-life situations that lead to the same mathematical problem: How do you find one side of a right triangle if you know the other two sides? The question is answered by a simple computer-animated derivation of the Pythagorean theorem based on similar triangles. The Pythagorean theorem is then used to solve the three real-life problems referred to above. Historical context is provided through stills showing Babylonian clay tablets and various editions of Euclid's *Elements*. The video exhibits several different computer-animated proofs of the theorem of Pythagoras and extends the theorem to three-dimensional space. The program then shows how the Pythagorean theorem is used in trigonometry and points out that the theorem does not hold for spherical triangles. Each video is accompanied by a workbook designed to help instructors incorporate classroom activities. The workbook briefly outlines the video program and gives suggestions of what the teacher can do before showing the tape. Each section summarizes the important points in the video segment. Some sections contain exercises that emphasize key ideas, words and phrases, and applications. Some sections suggest student projects. (AM) ENC-000896

Ordering Information
NASA CORE/Lorain County JVS, 15181 Route 58 South, Oberlin, OH 44074
(440) 775-1400 / Fax: (866) 775-1460 / Toll-free: (866) 776-2673
www.core.nasa.gov
$29.95 per video

Totally Tessellated

library.advanced.org/16661
Grades 5-12
1998
Contributor(s): Alok Bhushan, Eleanor Williams, and Kendrick Kay
Publisher: Advanced Network and Services, Inc

Created by three high school students, this web site is a comprehensive introduction to the creation and artful application of tessellations. It includes many colorful examples of tessellations found in real life and in the works of M.C. Escher. Animated demonstrations with explanations describe the development of fundamental tessellations with triangles, quadrilaterals, pentagons, and hexagons. The basic structures of tessellations are defined in mathematical terms that include angle measure, rotation, symmetry, and translation. The site develops the role of tessellations in history and in world cultures in terms of practical applications, such as an illustrated discussion of the relationship among tessellations, symmetry, and X-ray crystallography. Many hands-on activities and templates encourage the exploration and creation of tessellations. Visitors will also find a glossary of terms and links to other tessellation sites. (Author/JRS) ENC-013434

Visual Solid Geometry

Series: Visual 2000
Grades 9-12
1999
Contributor(s): Edu2000 Design Team

Part of the Visual 2000 series, this CD-ROM explores the full curriculum content of solid geometry with a blend of text, computer graphics, and three-dimensional animation. It is part of a 5-disc series designed to provide a resource base of high school mathematics for teachers, students, and parents. On this CD-ROM, each solid geometry topic features three sections: text and graphics with the mathematical explanation, an animation illustrating the concept, and an exercise, with solution, for applying the concept. Topics include solids of revolution, diagonals of a polyhedron, the frustum for a pyramid, and details for the construction of a regular icosahedron. As an example, a brief introduction to fractal geometry discusses how a modern non-Euclidean geometry, fractal geometry, is needed to explain the shapes of some natural phenomena, such as clouds, coast lines, mountain ranges, rivers, and trees. A fractal is described as an identical motif repeated on an ever-reduced scale. The animation illustrates this definition to explain the order and pattern found in the trunk and branches of a tree. Also found on this CD-ROM is a list of related mathematical web sites. (Author/JRS) ENC-016529

Ordering Information
Edu2000 America Inc, PO Box 2636, Carson City, NV 89702
(775) 887-1744 / Fax: (775) 887-1479 / Toll-free: (800) 930-3212
www.education2000.com
$39.00 per CD-ROM package (Windows/Macintosh)

Number and Operations

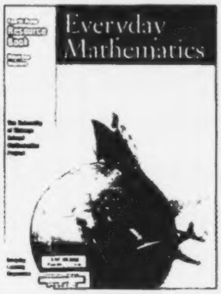
The Fibonacci Numbers and the Golden Section

www.mcs.surrey.ac.uk/Personal/R.Knott/Fibonacci/fib.html
Grade 7 and up
1996
Contributor(s): Ron Knott
Publisher: Surrey University, School of Electronic Engineering, IT and Mathematics, Department of Computing

This web site is devoted to the Fibonacci numbers, their properties and occurrences in nature, and related number theory topics. Visitors will find puzzles with answers involving the Fibonacci numbers, and examples of the Fibonacci numbers in art, architecture, and music are included. The site contains illustrations, diagrams, and graphs relating Fibonacci numbers to branching plants and to family trees for rabbits and bees. Other topics include the Golden Ratio, its properties and uses in geometry, and the Lucas number series. There are links to other sites of interest on the Fibonacci numbers and a listing of related books and articles. (Author/JRS) ENC-011674

Fourth Grade Everyday Mathematics Teacher's Resource Package

Series: Everyday Mathematics
Grade 4
1999
Contributor(s): Amy Dillard, Eleanor Yura, Herb Price, James Flanders, James McBride, Kathy Little, Laurie Leff, Marissa Penrod, Mary Jo Hustoles, Max S. Bell, Peggy Holm, Peter Saecker, Randee Blair, Robert Balfanz, Robert Hartfield, Sheila Sconiers, and William M. Carroll
Publisher: Everyday Learning Corporation



In this resource package, teachers will find mathematics lessons that emphasize discussion, problem solving for everyday situations, and discovery with hands-on experiences. Topics include solving number sentences, organizing data, and developing an intuitive sense about three-dimensional objects. The reform-based series from the University of Chicago School Mathematics Project is a complete K-6 mathematics curriculum program. Using a spiral approach, the series develops the following seven content strands: Algebra, Exploring Data and Chance, Geometry and Spatial Sense, Measures and Measurement, Numeration and Order, Operations, and Patterns. The strands contain familiar elementary mathematics topics as well as applications intended to motivate the student and provide a context for the traditional arithmetic. In this grade 4 program, students experience a yearlong expedition around the world, starting in Washington, D.C. and then continuing on through five regions of the world. Students use mathematical skills to determine air miles traveled, to read tables for information, and to keep a log of their travels. This kit has five components: a teacher's manual and lesson guide; a resource book with blackline masters for parent communication, student activities, and assessment; a world tour guidebook with maps, data, essays, games, and recipes for the tour project; two consumable student workbooks with problems for solution and pages to record the results of lesson-specific activities); and a scope and sequence chart broken down by months. Also included is a teacher's reference manual with background information on content, curriculum, and pedagogy. An assessment guide contains classroom-tested techniques and masters for inventories, self-assessment, and more formal assessment of grade-specific activities. A guide for teachers and administrators delineates how to familiarize families with this series. In a sample activity on organizing data, students work with a partner as they guess, estimate, and finally count objects such as raisins, macaroni, or beans in a container. Students organize the combined class results, record them on a table or graph, and analyze the data by discussing maximum, minimum, range, and mode. In the final activity, the class estimates the quantity of raisins (or other objects) found in a larger container. (Author/JRS) ENC-012102

Ordering Information
McGraw-Hill Companies, 220 East Danieldale Road, Desoto, TX 75115
(212) 512-2000 / Fax: (972) 228-1982 / Toll-free: (800) 442-9685
www.mcgraw-hill.com
$190.80 per teacher resource package
$13.80 per set student materials, reorder
$19.08 per set student materials, initial purchase

Math at Hand

Grades 4-6
1999
Contributor(s): Carol DeBold, Edward Manfre, Justine Dunn, and Susan Rogalski

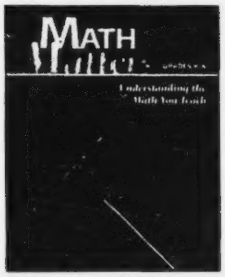
A Mathematics Handbook
MATH AT HAND

This handbook provides detailed and illustrated mathematical explanations of topics ranging from mental computation and problem solving to pre-algebra, probability, and geometry. The handbook complements the student textbook by offering alternative explanations of topics. It also serves as a resource for interdisciplinary projects with information on conversion tables, time zones, map reading, and ideas for science fair projects. In the pre-algebra chapter, a discussion about writing expressions includes four illustrated examples of how a word expression and an algebraic expression can be used to express a relationship. The scenario for the four examples begins with a full box of pencils. In the first example, the meaning of adding three pencils is shown in a picture, in a word expression, and in an algebraic expression. Next, the result of taking three pencils from the box is described in the three modes. Finally, the meaning and expressions related to three full boxes of pencils and a full box of pencils shared equally among three people are given. This handbook includes an almanac section with math prefixes and suffixes, problem-solving strategies, study tips, guidelines for using spreadsheets and databases, and test-taking strategies. Included as well is a yellow pages section, which has glossaries of formulas and of mathematical terms with extensive cross-referencing. (Author/JRS) ENC-014822

Ordering Information
Great Source Education Group, 181 Ballardvale Street, Wilmington, MA 01887
(978) 661-1511 / Fax: (800) 289-3994 / Toll-free: (800) 289-4490
www.greatsource.com
$17.00 per handbook (hardcover)

Math Matters, Grades K-6

Grades K-6
2000
Contributor(s): Art Johnson, Suzanne H. Chapin, and Joni Doherty



Topics in this teacher resource book range from computation to probability and statistics. Information is intended to help both new and experienced teachers deepen their understanding of elementary mathematics. The authors present information that meets the needs of teachers with limited background while still being useful to teachers with more mathematical knowledge. Chapters begin with a brief introduction followed by numbered sections that address different aspects of the topic. Each section explains the fundamental mathematical concepts of the topic and introduces and defines related terms. Interspersed throughout are 87 activities designed to bring meaning to the mathematical information. Activities are suitable for teacher study groups or for working on with a colleague. In a chapter that explores computation, the three sections discuss mathematical properties, basic facts, and algorithms. The algorithm section contains samples of student work that challenge the reader to consider how students think about each operation. For multiplication, three algorithms with discussion and illustrations show how the algorithms apply the distributive property and are related to the area model for multiplication. (Author/JRS)
ENC-020517

Ordering Information
Math Solutions Publications, Suite 101, 150 Gate 5 Road, Sausalito, CA 94965
Fax: (415) 331-1931 / Toll-free: (800) 868-9092
www.mathsolutions.com
$24.95 per book (paperback)

Mathematics for Elementary Teachers via Problem Solving

Grades PreK-5
2002
Contributor(s): Anne Miller Raymond, Frank K Lester, and Joanna Osborne Masingila
Publisher: Prentice Hall

Using a problem-solving approach, this activity manual and resource handbook are written to enable teachers and preservice teachers to explore mathematics content and pedagogy principles. The books were developed for professional development classes and comprise 10 chapters, each devoted to core mathematics concepts such as numeration, fraction models, and measurement. The activities in the manual are designed to be worked in cooperative groups with hands-on explorations. Each chapter begins with an overview, a list of the big mathematical ideas, and a correlation to the *Principles and Standards for School Mathematics* (NCTM 2000). Activities are linked to topics in the resource handbook with examples, discussions, and explanations of the mathematics concepts. In a sample chapter about number theory, users are introduced to prime and composite numbers. They investigate the concepts of divisibility, greatest common denominator, and least common multiple-- concepts fundamental to understanding operations on fractions. Users make conjectures, decompose numbers, and create multiple representations. In one activity, they examine patterns that are illustrated with patchwork-like blocks and with a number sentence, then extend and generalize the pattern. (Author/JRS)
ENC-021118

Ordering Information
Prentice Hall School Division, PO Box 2500, Lebanon, IN 46052
Fax: (877) 260-2530 / Toll-free: (800) 848-9500
www.phschool.com
$26.67 per student resource handbook (paperback)
$48 per student activity manual (paperback)

A Mathematics Source Book for Elementary and Middle School Teachers

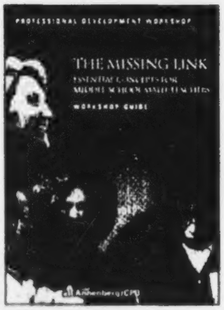
Grades K-8
1999
Contributor(s): Bay Area Mathematics Task Force, San Francisco State University (SFSU)
Publisher: Arena Press, a Division of Academic Therapy Publications

This teacher resource book features a discussion of mathematics topics commonly taught in the elementary and middle school curriculum. Each chapter covers a specific topic, such as multiplication, fractions, or algebra foundations. Information for each topic includes the underlying mathematics concept, advice on how to strengthen teaching and learning, and the common misunderstandings students have of the topic. As an example, the chapter on percent discusses the use of percents to report statistics, to describe functional relationships for scaling up or down, to represent part-whole relationships, and to make comparisons or to note change over time. Teaching tips include stressing that two quantities need to be known before establishing a percent, using percents to represent general constant relationships, and teaching exponential growth. The chapter also addresses potential pitfalls, such as detaching meaning from percents. Readers will find assessment questions and suggestions for ways to develop computational fluency. Research resources for all topics are at the end of the book. (Author/JRS)
ENC-018797

Ordering Information
Arena Press, 20 Commercial Boulevard, Novato, CA 94949
Fax: (888) 287-9975 / Toll-free: (800) 422-7249
www.atpub.com
$18.00 per source book (spiral-bound)

The Missing Link

Series: Annenberg/CPB Professional Development Workshop.
Grades 6-8
2000
Contributor(s): Kay Lavine and Miriam Lewin



The 8 videos and guidebook in this kit are designed to help middle school teachers increase math content knowledge in four areas and expand their teaching style. The materials were developed in response to teaching and learning challenges identified by the Third International Mathematics and Science Study (TIMSS). The kit highlights ways teachers can use hands-on problems that involve students in their own learning and demonstrate how math is used in the real world. The workshop guide describes how to present the videos in either a two- or four-hour workshop format. Also available is a web site with supporting material and links to online resources. Each of the four content areas (proportionality, functions, angles and polygons, and sampling and probability) is featured in two videos. In the first video for each content area, a master teacher and a workshop guide lead a group of learner teachers through hands-on investigations. The viewer then sees how the teachers present the hands-on investigations in their middle school classrooms. In the second video the viewer sits in on a studio discussion as the teachers reflect on their experiences and consider new instructional and assessment techniques. For example, in the videos focusing on proportionality, the learner teachers are introduced to the concept of scale factor, use scale factor to enlarge and shrink figures, and determine how scale factor affects side lengths, angles, perimeters, and area. The master teacher explains how to develop scoring methods or rubrics for assessing student work in the scale factor investigations. The teachers, working in groups, practice using the rubrics they developed with samples of student work. Finally, the teachers work together to create new problems to deepen their students' understanding of proportionality and similar figures. (Author/JRS) ENC-019737

Ordering Information
Annenberg/CPB, PO Box 2345, South Burlington, VT 05407
(802) 862-8881 / Fax: (802) 846-1850 / Toll-free: (800) 532-7637
www.learner.org
$25.00 per guide (spiral-bound)
$199.00 per 8 video set and one guide (spiral-bound)

Number and Operations, Part 2: Making Meaning for Operations

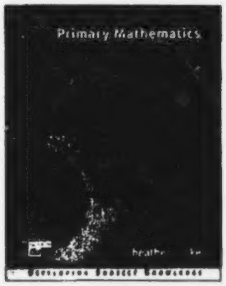
Series: Developing Mathematical Ideas
Grades K-6
1999
Contributor(s): David A. Smith, Deborah Schifter, Jill Bodner Lester, Linda Ruiz Davenport, Lisa Yaffee, Sophia Cohen, Susan Jo Russell, and Virginia Bastable

Part of the Developing Mathematical Ideas program, this professional development kit is designed to help current and future teachers explore the meaning of arithmetic operations and how students develop these concepts. The program offers field-tested seminars that examine the big ideas in elementary school mathematics. Each seminar is designed as a stand-alone course that includes a facilitator's guide, a casebook for each participant, and a video of actual students in classrooms organized around student thinking. The participant's book for this seminar contains 28 cases exploring the types of actions and situations modeled by addition, subtraction, multiplication, and division. It also explores the ways students come to understand these operations for whole numbers and fractions. The casebook is divided into chapters that correspond to the eight sessions of the seminar. The introduction to each chapter describes the set of cases, highlights the mathematical themes they address, and provides questions to consider while reading the cases. At each session, participants discuss the cases and take part in a related mathematics activity designed to be challenging to adult learners. Participants look at and discuss innovative curricular materials, consider research findings related to mathematics education, and create and discuss a portfolio of their assignments. References are included. (Author/JRS) ENC-018073

Ordering Information
Dale Seymour Publications, PO Box 2500, Lebanon, IN 46052
(800) 237-3142 / Fax: (800) 393-3156 / Toll-free: (800) 526-9907
www.pearsonlearning.com
$69.95 per facilitator's package
$32.95 per facilitator's guide (paperback)
$13.95 per video

Primary Mathematics

Series: Developing Subject Knowledge
Grade: Post-secondary
2000
Contributor(s): Heather Cooke
Publisher: Paul Chapman Publishing Ltd.



Part of the Developing Subject Knowledge series, this self-study book is written for both preservice and experienced teachers who need to develop their mathematics knowledge and understanding. The series provides active learning for the under-confident learner and offers self-directed learning materials to help British teachers satisfy national requirements for teaching the primary curriculum in English, mathematics, and science. This task-driven book contains seven stand-alone sections designed to be studied in any order. It features illustrations, margin notes, and icons indicating related practice problems and when calculator and computer use are appropriate. The book explores common mathematical misconceptions and includes a self-assessment section with guidance on how to study effectively. For example, the chapter titled Proof and Reasoning explores what types of reasoning are convincing and suggests ways to make reasoning more precise. In one activity, the reader is challenged to investigate number relationships with the following set of directions: Take any two numbers that add up to 1. Square the larger and add the smaller. Square the smaller and add the larger. Which result will be bigger? The reader forms a conjecture and considers how to convince someone else of the truth of the conjecture. (Author/JRS) ENC-020768

Ordering Information
Corwin Press, Inc., 2455 Teller Road, Thousand Oaks, CA 91320
(805) 499-9734 / Fax: (805) 375-1700
www.corwinpress.com
$25.95 per book (paperback)

Reconceptualizing Mathematics

Series: Reconceptualizing Mathematics
Grades K-8
1999
Contributor(s): Judy Sowder

This set of CD-ROMs is a research-based curriculum development project. The project focuses on helping prospective elementary and middle school teachers create instructional materials for mathematics courses. The goal is to provide materials and courses that will help these teachers, as well as experienced classroom teachers, to reconceptualize the mathematics they often think they already know. The set consists of five CD-ROMs of teacher materials, teacher notes, and student materials, as well as quicktime movies of vignettes to support the materials. The CDs cover the following five modules: Number and Number Sense; Shapes and Measurement; Chance and Data; Quantitative Reasoning; and Describing Change. The authors emphasize the importance of using technology where appropriate and using research in mathematics education to inform decision making. In the section on quantity, for example, student teachers answer questions such as: How long do humans live? and How big is this room? The distinction is then drawn between the value of a quantity and the quantity itself. In the next activity, student teachers identify the quantity or quantities in questions such as, How tall is the Eiffel Tower? In the final activity, participants talk in groups about the ease or difficulty of quantifying certain things such as blood pressure, air quality, teaching effectiveness, or livability of a city. (Author/MM) ENC-018880

Ordering Information
Center for Research in Mathematics and Science Education, San Diego State University, 6475 Alvarado Road #206, San Diego, CA 921120
(619) 594-1587 / Fax: (619) 594-1581
$40.00 5 CD-ROMs (Macintosh/Windows)

Teaching Fractions and Ratios for Understanding

Grades 3-8
1999
Contributer(s): Susan J. Lamon
Publisher: Lawrence Erlbaum Associates, Inc.

This book concentrates on enhancing teacher's mathematics content knowledge and understanding, examining student thinking, and exploring teaching methods, instructional activities, and assessment. Author Susan Lamon believes that using the same questions and activities given to students enables teachers to build comfort and confidence in their ability to teach complex ideas. The problems and activities are designed to be useful in elementary and middle school classrooms and during family math nights. Each chapter includes self-assessment sections that invite the reader to stop and work examples before continuing; in addition, there are activities to try out the new ideas presented. Mathematics concepts are developed through detailed illustrations. Excerpts of student work give the reader an idea of what to expect from students. An extensive bibliography offers further reading about the development of proportional reasoning and other rational number concepts. (Author/JRS) ENC-018784

Ordering Information
Lawrence Erlbaum Associates Inc, 10 Industrial Avenue, Mahwah, NJ 07430
(201) 236-9500 / Fax: (201) 760-3735 / Toll-free: (800) 926-6579
www.erlbaum.com
$18.00 per supplement (paperback)
$29.95 per book (paperback)

The Universal History of Numbers

Grade K and up
2000
Contributor(s): Georges Ifrah, David Bellos, E. F. Harding, Ian Monk, and Sophie Wood
Publisher: John Wiley and Sons Inc.

This book describes the development of the modern number system from ancient times to the present. It contains a history of numbers from all over the world, beginning with the origins of the first numbers. Discussion focuses on the changes civilizations made to their number systems over time. The text also addresses the difficulties that certain numbers--zero, negative numbers, and irrational numbers--presented to ancient mathematicians. The book describes and illustrates number representations through tallies, finger counting, to body parts, numerals of all kinds, verbal explanations, and other forms of symbolic notation. The different number system's processes for making calculations, such as using an abacus or an algorithm, are discussed in detail. The book concludes with a summary of the recent advances in modern notation through the development of successive algebraic extensions of the concept of number to the real line and beyond. Included are graphs and charts of numerals, a bibliography, a dictionary of Indian numerical symbols, and directions for calculating Indian numerals in the Islamic world and other types of manipulations. (Author/SB) ENC-020219

THE UNIVERSAL HISTORY OF NUMBERS

Ordering Information
John Wiley and Sons, Inc., One Wiley Drive, Somerset, NJ 08875
(908) 469-4400 / Fax: (732) 302-2300 / Toll-free: (800) 225-5945
www.wiley.com
$39.95 per book (hardcover)

Data Analysis and Probability

The Cartoon Guide to Statistics

Grade 11 and up
1993
Contributor(s): Larry Gonick and Woollcott Smith
Publisher: HarperPerennial

Central ideas of modern statistics are illustrated for the non-mathematician with words, formulas, and cartoon-like sketches. Information is organized into three related disciplines: data analysis, probability, and statistical inference. The authors present the elements of statistics in graphical ways while incorporating some algebra. Statistics applications are featured with the theoretical introduction of topics to help the reader appreciate the usefulness of statistics. For example, later chapters focus on statistical inference, the science of drawing statistical conclusions from specific data using a knowledge of probability. The reader learns about making statistical inferences in election polling, quality control in manufacturing, medical testing, and environmental monitoring. The bibliography includes descriptions of statistical software, further readings for the statistics student, and references about the misuse of statistics. (Author/JRS) ENC-019414

Ordering Information
HarperCollins Publishers, Inc., PO Box 588, Scranton, PA 18512
(212) 261-6500 / Fax: (800) 822-4090 / Toll-free: (800) 242-7737
www.harpercollins.com
$16.00 per book (paperback)

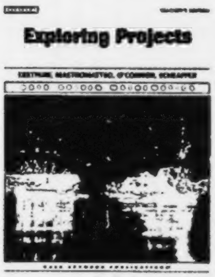
Exploring Data

exploringdata.cqu.edu.au
Grades 10-12
1997
Contributor(s): Rex Boggs
Publisher: Queensland, Department of Education

The material on this web site, developed by an Australian mathematics teacher, includes activities, worksheets, and overhead transparency masters for introductory statistics. Also included are data sets, complete with stories about their origins, and assessment to support data exploration. The site emphasizes the importance of extending teachers' knowledge of statistics and the central place of real data in students' understanding of the subject. To help visitors explore such concepts as stemplots, normal distribution, and probability, the site offers teacher notes on the meaning and relevance of the concept, plus extension articles directly available as downloadable documents or as links to web pages. Furthermore, activities are outlined and accompanied by sets of real data. A resource page contains a list of resources available to support introductory statistics. Links to tutorials and other mathematical web sites are included. Winner, ENC Digital Dozen, August 1999. (Author/JRS) ENC-011678

Exploring Projects

Series: Data-Driven Mathematics
Grades 8-12
1999
Contributor(s): Emily Errthum, Maria Mastromatteo, Richard L. Scheaffer, and Vince O'Connor



Part of the Data-Driven Mathematics series, this textbook and the accompanying teacher's guide are written to help algebra students use real-world data to develop their thinking about conducting surveys and experiments. Designed to complement a secondary school mathematics curriculum in the process of reform, the series comprises 12 books in five modules: Introductory Algebra, Algebra, Geometry, Advanced Algebra, and Advanced Mathematics. The first section of this book covers censuses; the second, surveys; the third, experiments; and the fourth, projects. Each lesson is designed around a problem or mathematical situation. It begins with a series of introductory questions or scenarios that can prompt discussion and raise issues about that problem. The teacher's guide provides extensive notes for the student book and contains answer keys, quizzes, an end-of-module test, and activity sheets. As an example, in the lesson "Selecting a Sample," the motivating questions are: Can just anyone be asked to participate in a survey? and How should you choose people to participate? The lesson begins with a discussion of sampling bias and continues with some questions about randomness. The lesson concludes with practice and application questions as well as a summary of the main concepts explored. (Author/MM) ENC-019461

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Dale Seymour Publications, PO Box 2500, Lebanon, IN 46052
(800) 237-3142 / Fax: (800) 393-3156 / Toll-free: (800) 526-9907
www.pearsonlearning.com
$22.95 per teacher's edition (paperback)
$17.95 per student edition (paperback)

Exploring Surveys and Information from Samples

Series: Quantitative Literacy
Grade 10 and up
1987
Contributor(s): Ann E. Watkins, James M. Landwehr, and Jim Swift

This textbook and accompanying teacher's guide, part of the Quantitive Literacy series, are written to help students learn the basics of statistical inference by studying sample opinion polls. The series consists of five books which are written with the goal of making it possible for teachers to introduce the most up-to-date topics in statistics and probability into their middle school and high school classrooms. The textbook consists of a series of thirty-two applications and explanatory text related to polling, and addresses topics such as box plots, confidence intervals, methods of sampling, and the design of surveys. Some goals for student learning are for readers to understand how statisticians use sampling to get information about a population, be able to understand and comment critically on newspaper and other reports of surveys and opinion polls, and be able to conduct an elementary survey and report on possible errors and bias. In the section on methods of sampling, for example, the definition of a random sample is stated and discussed. As an application, students are presented with questions about random and representative samples. The section continues with a discussion of different ways of obtaining a sample, including convenience sampling, judgment sampling, and cluster sampling. The next application consists of questions about the different kinds of sampling presented and the benefits and limitations of each. The section concludes with an analysis of survey bias and an application with questions about evaluating bias in surveys. The accompanying teacher's guide provides an overview of the textbook's content, general teaching notes, and specific teaching suggestions for each page of the textbook. Complete solutions to the applications and a series of test and quizzes with complete solutions are also included. (Author/MM) ENC-020766

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Dale Seymour Publications, PO Box 2500, Lebanon, IN 46052
(800) 237-3142 / Fax: (800) 393-3156 / Toll-free: (800) 526-9907
www.pearsonlearning.com
$15.95 per teacher's edition (spiral-bound)
$13.95 per student text (paperback)

Insights into Data

Series: Mathematics in Context
Grades 8-9
1998
Contributor(s): Gail Burrill, Jan de Lange, Mary C. Shafer, and Monica Wijers

This statistics unit introduces students to critical analysis of data sets and data representations. The unit is part of a comprehensive curriculum for middle grades developed and field-tested by the National Center for Research in Mathematical Sciences Education at the University of Wisconsin-Madison. During this three-week unit, students collect and examine data as they grow sprouts from mung beans in solutions containing either salt, cola, lemon-lime soda, or plain tap water. Sprouts are measured for 14 days, after which students use graphical and numerical methods to describe and analyze the data collected on plant growth. Methods include finding mean, median, and mode, and learning to create and interpret scatter plots, bar graphs, histograms, and box plots. Students also use census data, world population data, baby growth, bird egg sizes, and bluegill fish growth patterns as they learn to recognize bias in sample surveys. They examine misleading representations of data and identify correlations. The teacher's guide includes suggestions for informal assessment and a set of blackline masters containing a letter to families, student activity sheets, and assessment masters. The series is designed to reflect the 1989 NCTM standards. (Author/JRS) ENC-011853

Ordering Information

Encyclopedia Britannica Inc., Mathematics in Context, 310 South Michigan Avenue, Chicago, IL 60604
Fax: (312) 347-7966 / Toll-free: (800) 554-9862x7007
www.britannica.com
$21.55 per teacher guide
$5.35 per student book

A Mathematician Reads the Newspaper

Grades: 9 and up
1995
Contributor(s): John Allen Paulos
Publisher: Anchor Books

of 8 gulps
toxic top

The collection of short pieces in this book examines the mathematical angles of news stories. The book is divided into sections that address such areas as economics, sports, science, and business. The author believes that mathematics is not primarily a matter of performing rote computations, but is instead a way of thinking and questioning. The book gives readers an appreciation of math's role in understanding social issues and a sense of its uses, nonuses, misuses, and abuses in the daily paper. Specific topics addressed include voting, quotas, the use of DNA evidence in the legal system, the reporting of health risks, and interpretation of SAT scores. (Author/MM) ENC-019364

Ordering Information
Random House, Inc., 400 Hahn Road, Westminster, MD 21157
(410) 848-1900 / Fax: (800) 659-2436 / Toll-free: (800) 793-2665
www.randomhouse.com
$12.95 per book (paperback)

Seeing Statistics

www.seeingstatistics.com
Grade 10 and up
2000
Contributor(s): Gary McClelland
Publisher: Duxbury

The Duxbury Press maintains this web site to help students of statistics learn the dynamic, visual nature of statistical concepts using interactive methods. The site uses more than 150 Java applets and text to create a web book that is a first course in statistics. The topics include measures of central tendency, measures of spread, the normal distribution, hypothesis testing, and linear regression. The site is accompanied by a user's guide in book form that provides users with a password to gain access to the site. Each chapter begins with an introduction and a section called Why Am I Learning This? On each page there are links to applications of the topic in other subject areas, and there is also a help button. In most cases, students can enter their own data for use in the applet. The guidebook also provides an overview of the web book, a detailed tour of one chapter, a comprehensive illustrated list of the applets, and a brief discussion of examples in psychology and other subjects. In addition, the guidebook includes a guide to statistics software, a glossary of statistical terms, and a list of references. (Author/MM) ENC-019487

Statistics

Series: Used Numbers: Real Data in the Classroom.
Grades: 4-5
1989
Contributor(s): Rebecca B. Corwin and Susan Jo Russell.

In this unit of study, students collect real data through observation, experiments, and surveys and then represent data with models, tables, graphs, and diagrams. They also describe features of the data, formulate hypotheses, and build theories about the reality represented by the data. The unit is organized into investigations that develop concepts and skills such as deciding how to count or measure data, developing informal ways of summarizing the key features of a data set, and comparing data sets. Each investigation includes a summary of the student activity, a list of needed materials and mportant mathematical ideas, and step-by-step suggestions that outline the students' explorations and the teacher's role. Dialog boxes illustrate the special role of discussion in these investigations and typical student-teacher interactions. The unit also includes a general discussion of data analysis and pedagogical techniques, such as small-group work, materials to represent data, calculators, home/school connections, and interdisciplinary connections. Completion of the unit requires approximately 17 class sessions of about 45 minutes each. (AM) ENC-000670

Ordering Information
Dale Seymour Publications, PO Box 2500, Lebanon, IN 46052
(800) 237-3142 / Fax: (800) 393-3156 / Toll-free: (800) 526-9907
www.pearsonlearning.com
$16.95 per text

Math on the Cutting Edge

Chaos

Series: The Toolkit of Dynamic Activities
Grades 7-12
2000
Contributor(s): Jonathan Choate and Robert L. Devaney

This resource book, part of the Toolkit of Dynamic Activities series, is written to help high school math teachers introduce the mathematical concept of chaos. It is designed to be integrated into programs of study in algebra, geometry, and precalculus. It consists of 10 lessons covering linear and nonlinear iteration with fixed points, cycles, and orbits through both graphical iteration and orbit diagrams. Each lesson starts with teacher notes giving detailed advice on how to plan for and organize the lesson. This is followed by the mathematical content of the lesson and blackline masters that lead students through a guided discovery of the content. Each lesson includes tips for the use of technology to enhance the lesson and concludes with problems for further investigation. For example, in the lesson on measuring population growth, students develop the logistic model of population growth. Students begin by looking at the exponential growth model before refining and improving that model. The lesson includes an explanation of both the exponential and logistic model as well as a discussion of the parameters of each model. Among the further explorations is a comparison between orbit diagrams for logistic models and for the quadratic iteration rule. Complete answers to the worksheets are provided as an appendix. (Author/MM) ENC-019103

Ordering Information
Key Curriculum Press, 1150 65th Street, Emeryville, CA 94608
Fax: (800) 541-2442 / Toll-free: (800) 995-6284
www.keypress.com
$17.95 per book (paperback)

Fantastic Fractals Online!

www.techlar.com/fractals/websys.exe?file=index.html
Series: ThinkQuest Competition
Grade 4 and up
2000
Contributor(s): John Sheu, Luke Shulenberger, and Mike Turvey
Publisher: Techlar Innovations

The tutorials at this web site present information about the mathematics behind fractals and interactive activities for exploring the nature of fractals. Two tutorials, one for older students and one appropriate for younger students, offer step-by-step explorations of the terms and processes related to the formation of fractals. Visitors will also find interactive applications for exploring fractal formation. Another section, Fractal Explorer, contains applets for investigating the structure of the Mandlebrot set, Julia set, and the Sierpinski triangle. In the Fractal Workshop, users can create fractals and post the results online. An image gallery displays simple fractals and realistic images generated with fractals to model things in nature. Questions about fractals can be posted and answered on a message board. (Author/JRS) ENC-018758

Fractals

Grades 7-12
1992
Contributor(s): John Briggs
Publisher: Touchstone Book

This illustrated book explores fractals and patterns of chaos as visual, artistic links to mathematics and science. It shows and describes the significance and the beauty of fractals, which are found in nature and can be generated by the computer using an iterative process. In a unique approach, the author suggests that the book be read in a nonlinear fashion, either by following the reader's whim to learn more about some aspects of fractal/chaos topics or by following path-of-interest buttons through the book. These buttons lead to topics such as the Mandelbrot set, biofractals, and space. Linear and nonlinear systems, chaos theory, and dynamical systems are some of the underlying mathematics and science topics described and illustrated. Illustrations and discussion link mathematics, science, and visual representations. Examples include a picture of Jupiter's giant swirling eye taken by Voyager 1, the fractal patterns created by starfish bodies washed up on rocks, and Euclidean geometric forms found in a 16th-century Flemish painting. The book includes software for creating fractals on home computers. (Author/JRS) ENC-020289

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www.pearsonlearning.com
$24.95 per book (paperback)

In Code

Grade 11 and up
2001
Contributor(s): David Flannery and Sarah Flannery

A MATHEMATICAL JOURNEY
In Code

Track the mathematical progress of Sarah Flannery in this autobiographical sketch, which ranges from her very early years to her development of a fast public key cryptosystem. The book explains her interest in mathematical puzzles, her attempts to solve them, and her eventual success in cryptography. Readers are given the mathematical information necessary to understand each of the puzzles Flannery works on, from magic squares to her development of the Cayler-Purser algorithm. The mathematical content is informally and humrously presented with dialogue between the author and the reader. Frequently, the author encourages the reader to try and solve a puzzle before going on, and some of the answers to puzzles are only given in an appendix at the end of the book. As an example of the mathematical material covered, the author explains the basis behind modern codes: any two random prime numbers consisting of more than 100 digits each can easily be multiplied with a computer. When this two-hundred-digit product is used to encode a message, decoding the message requires factoring it into its primes, a task that is not feasible if neither of the factors is known. Flannery then gives an example of a two-hundred-digit prime number and asks: Can you factor it and would you want to? The answers to these question are in the appendix. (Author/SB) ENC-020325

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Workman Publishing Co., 708 Broadway, New York, NY 10003
(212) 254-5900 / Fax: (212) 254-8098 / Toll-free: (800) 722-7202
www.workman.com
$24.95 per book (hardbound)

Life by the Numbers

Series: Life by the Numbers
Grades 7-12
1997
Contributor(s): David Elisco, Gina Cantanzarite, Joe Seamans, and Mary Rawson
Publisher: WQED

This video contains 13 short modules of material excerpted from the series Life by the Numbers. Each module illustrates the underlying importance of mathematics to everyday life. Mathematical applications as diverse as the way statistics is used and misused in making election predictions and why an ape could never grow to be the size of King Kong are explored. The series offers seven hour-long videos that highlight the use of numbers to analyze the motion of athletes; to explain the links between computer graphics, topology, and virtual reality;

and to map outer space and the ocean depths. The five-to 10-minute modules in this video were chosen by teachers for their connection to a typical high school mathematics curriculum. The accompanying teaching guide contains a four-page spread covering each episode in the series, including classroom activities for each. The guide offers a thematic program overview, information on key concepts treated, and classroom activities. Also included is a description of a school math trail with activities geared to locations likely to be found in most schools. Students work with proportion and scale, the tangent function, slope, and patterns and fractals, while answering questions related to their school. (Author/JRS) ENC-014138

Ordering Information
Texas Instruments, Inc., Attn: Accessories, PO Box 650311 M/S 3962, Dallas, TX 75265
Fax: (972) 917-0747 / Toll-free: (800) 842-2737
www.ti.com/calc
$4.95 per video with teaching guide

Mathematics

Grade 11 and up
1999
Contributor(s): Keith Devlin
Publisher: Columbia University Press

mathematics
the new golden age
Keith Devlin

Written to appeal to readers at any level of mathematical understanding, this book presents major advances in mathematics in the twentieth century. The author chose 11 of the most famous problems that have been solved recently. Each problem is explained in detail, along with the history of attempts to solve it, the successful solution, and the real-world implications of the solution. Chapters that do not deal with a specific problem discuss the rapidly developing field of mathematics, which continuously changes the way mathematics, or even the universe, is regarded. In several cases, the author shows how problems have been solved not by a single person, but by several people working together. He also emphasizes the contribution of computers and the Internet to the solution of math problems. In the chapter about the four-color problem, the author describes the following challenge: find the minimum number of colors required to color any map so that no two areas that share a boundary would have the same color. Problems that arise in this question are discussed as well as the progress that was made using topology, graph theory, and computers. (Author/SB) ENC-019821

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Columbia University Press, 136 S Broadway, Irvington, NY 10533
(212) 666-1000 / Fax: (800) 944-1844 / Toll-free: (800) 944-8648
www.columbia.edu/cu/cup
$17.95 per book (paperback)

MegaMath

www.c3.lanl.gov/mega-math/welcome.html
Grades K-12
1995
Contributor(s): Nancy Casey
Publisher: Los Alamos National Laboratory

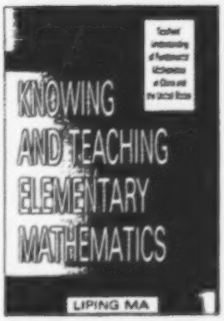
A project of the Computer Research and Applications Group at Los Alamos National Laboratory, the MegaMath web site brings unusual and important mathematical ideas to elementary school classrooms so that young people and their teachers can think about them together. MegaMath explores different mathematical ideas with activities and projects. For each idea, such information as vocabulary, concepts, and relevant NCTM standards (1989) are included. For example, the section on mathematical knots provides a variety of activities for exploring knots made from pieces of rope. Students can make and verify observations about knots, classify them, combine them, and find ways to determine if two knots are alike. The activities outlined here can be combined to form a single lesson about mathematical knots, or a larger investigative unit that extends over a longer period of time. The sequence in which the activities are listed is roughly in order of increasing difficulty and challenge, but all of the earlier activities are not strict prerequisites for the later ones. In another activity, students act out the workings of a finite state machine, and in doing so can understand how a finite state machine works and the kinds of patterns that it can recognize. They can then create guessing games for each other in which the object is to guess the structure of a finite state machine by finding out which words are accepted by the machine. (Author/DDD) ENC-002455

For Further Exploration in Mathematics

Knowing and Teaching Elementary Mathematics

Series: Studies in Mathematical Thinking and Learning
Grades 1-6
1999
Contributor(s): Liping Ma
Publisher: Lawrence Erlbaum Associates, Publishers

This professional book reports the findings of a research project that compared the subject-matter knowledge of elementary school mathematics teachers in the United States and China. Chinese students typically outperform U.S. students on international comparisons of mathematics competency. Studies of U.S. teachers often document their insufficient subject matter knowledge in mathematics, but they tend to give few examples of the knowledge teachers need to support teaching. This book describes the nature and development of the profound understanding of fundamental mathematics (PUFM) that teachers need to become accomplished mathematics teachers. Author Liping Ma suggests why such teaching knowledge is more common in China than in the United States, despite the fact that Chinese teachers have less formal education than their U.S. counterparts. The term *fundamental mathematics* refers to the foundational, primary, and elementary aspects of the mathematics taught in elementary school. Elementary mathematics is foundational because it forms the basis of the skills and knowl-



edge on which the more advanced mathematical disciplines depend. It is primary because it contains the rudiments of many important concepts in the more advanced branches of mathematics. The term *profound understanding* refers to the depth, breadth, and thoroughness of the knowledge that is required to be an accomplished teacher of elementary mathematics. Teachers with PUFM make connections between mathematical concepts and procedures, appreciate different facets of an idea and various approaches to a solution, and have an awareness of the simple but powerful foundational concepts and principles of mathematics. Such teachers are also knowledgeable about the whole elementary mathematics curriculum, not just the content of a particular grade level. (Author/GMM) ENC-015511

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www.erlbaum.com
$45.00 text (hardcover)

The Math Forum Internet Mathematics Library

mathforum.org/library
Grades K-12
1999
Contributor(s): Math Forum
Publisher: Math Forum, Drexel University

This online, annotated catalog of mathematics and mathematics education web sites was assembled by the Math Forum. It features hierarchical categories (mathematical topics, resource types, mathematics education topics, and educational levels) for browsing and a power searching feature for more defined searches. There is a description of each site in the catalog along with selected sites for each category and subcategory. On a monthly basis, a highlighted hot spot links to featured sites, such as Math Counts, Score Mathematics Lessons, and Mathematicians of the African Diaspora. Also found are search tips and a form for users to suggest additional sites for the library. (Author/JRS) ENC-014856

Math: Facing an American Phobia

Grade K and up
1998
Contributor(s): Marilyn Burns
Publisher: Math Solutions Publications

Math has gotten a bad reputation with the American public, and this book for parents and teachers provides possible reasons why this is so. The book also discusses what math can and should mean to people and explains how adults can avoid passing their math phobias on to their children. Author Marilyn Burns traces the underlying conflict between the public's assumption that mathematics means arithmetic and the belief of math educators that the mathematics taught in schools must foster reasoning, thinking, and problem-solving skills. The book begins by outlining the mathematics involved in preparing a holiday dinner: determining the size of the turkey, the amount of stuffing required, and the cooking time. Burns then compares this practical mathematics to what is taught in schools, explaining that there is a divide between the classroom emphasis on paper-and-pencil activities and the real-world application of mathematics. As an example, a chapter on pizza problems explores the meaning of doubling an object in size, the relationship between diameter and area, and processes of mathematical thinking and investigation. Other topics discussed are the value of timed math tests, the use of expanded student answers in student-teacher communication, and the appropriate use of the calculator. The final chapters contain practical suggestions to help children avoid math phobias. Burns recommends actively engaging children in mathematics outside the classroom and supporting and encouraging children throughout their math education. An answer key contains the solutions to the seven problems found in the book. Detailed explanations and illustrations of the reasoning behind the solutions are designed to help readers think mathematically. (Author/JRS) ENC-012250

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ETA/Cuisenaire, 500 Greenview Court, Vernon Hills, IL 60061
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www.etacuisenaire.com
$15.95 per book (paperback)

MATRIX

www.mathsyear2000.org/museum/outside.html
Grade: 7 and up
2000
Contributor(s): MathsDirect (UK)

Visitors to this extensive virtual museum can tour galleries of exhibitions illustrating mathematics- and science-related objects. Clicking on the pictures in each gallery brings up historical background information and related interactive applets. Examples of exhibits include a virtual abacus, nesting dolls, an armillary sphere, and scientific measuring devices such as cup weights and a navigator's parallel ruler. Gallery Eleven shows four paintings that contain images of technology from past centuries. At the exhibit for the Platonic Solids, the viewer can rotate and modify images of each of the solids. (Author/JRS) ENC-018208

Why Do Buses Come in Threes?

Grades 9-12
1998
Contributor(s): Jeremy Wyndham, Rob Eastaway, and Barbara Shore

This book demonstrates the links between mathematics ideas and real-world issues and situations. The goal is to show how mathematics is an essential part of life. The authors investigate the mathematics found in the coincidence of matching birth dates, the basis for the "accuracy" of horoscopes, and the patterns in the number and arrangement of petals on a flower and seeds in an apple. Cartoon-like illustrations, equations, and diagrams are used to answer questions about the mathematics underlying aspects of everyday life. Consider the following examples: How can a cake be sliced into seven pieces? Which day is the best day to buy a lottery ticket? Where can you get the best view of the Statue of Liberty? The answer to this last question applies the geometry of tangents to a circle to find the optimum viewing distance from the base of the statue. A bibliography is included. (Author/JRS) ENC-020284

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John Wiley and Sons, Inc., One Wiley Drive, Somerset, NJ 08875
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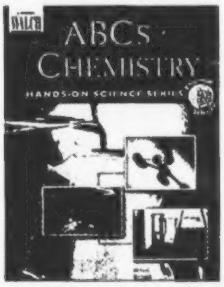
Chemical Science and Chemistry

ABCs of Chemistry

Series: Walch Hands-on Science Series: Physical Science
Grades 6-10
2000
Contributor(s): Lloyd Birmingham, W. Michael Margolin, and J. Weston Walch



Intended as an economical curriculum supplement, this book features 17 reproducible lessons that utilize household chemicals and common laboratory equipment. It is one of a series of hands-on activity books that explore physical science concepts. Experiments engage students in manipulating equipment, drawing inferences and conclusions from data, and applying scientific concepts. Topics for study include the process of making soap, the characteristics of acids and bases, and the physical properties of matter. Each activity contains background information, laboratory procedures, and extensions for further research. Accompanying student worksheets contain analysis and conclusion questions. In a sample experiment, "Why Won't the Ketchup Pour?", students read about non-Newtonian fluids and create two colloids by mixing cornstarch with water and white glue with sodium chloride. They then perform a series of tests on their products to compare and contrast the physical properties of each. Conclusion questions ask students to try and explain why ketchup is difficult to pour out of a bottle. Follow-up activities include investigating how ketchup reacts to various conditions, writing a report about colloids, and researching thixotropy. (Author/JG) ENC-018817

Ordering Information
J. Weston Walch Publisher, 321 Valley Street, PO Box 658, Portland, ME 04104
(207) 772-2846 / Fax: (207) 772-3105 / Toll-free: (800) 341-6094
www.walch.com
$19.95 per book (paperback)

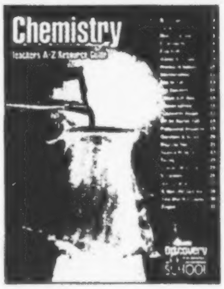
Chem4Kids!

www.chem4kids.com
Grades 4-10
2002
Contributor(s): Andrew Rader Studios

Chemistry topics available on this web site include matter, elements, and atoms, in addition to math and reactions. Each section of the site introduces the featured concept with clickable text that provides more detailed information. Users can browse through the entries on this site through a list of topics and subtopics, or they can use the detailed index associated with each topic. In a sample section on elements, students learn how scientists organize the periodic table. Clicking on one of the colored squares in the periodic table brings up information about each individual element. The math section shows students how math is used in chemistry and covers some of the units, constants, and symbols used in many of the formulas. The site allows students to take multiple-choice quizzes on what they have learned. It also offers a glossary in which students can find brief explanations of highlighted words on the text screen. Also provided are links to the KAPILI.COM homepage and other research labs (Astronomy, Biology4Kids, or Physics4Kids). (Author/YK) ENC-017111

Chemistry

Series: Teachers A-Z Resource Books
Grades 5-9
2000
Contributor(s): Joyce Lowry Weiskopf and Roberta Baxter



Developed as part of the Discovery Channel Science Collections series, this book provides science teachers and students with 32 pages of classroom tools for studying chemistry. Organized alphabetically from Activities to Zingers, each section offers a unique perspective on the nature of chemistry and chemical principles. Demonstrations, Just For Fun, and Science Projects contain hands-on investigations while Careers and Interdisciplinary pages illustrate how science is used in the real world. Reproducible student worksheets support the text along with an icon-based navigational system, which helps readers locate specific types of materials. A sample chapter, Noteworthy People, discusses the contributions of Antoine Lavoisier and Linus Pauling to the scientific community. Correlations to the NSES illustrate how studying science history is related to scientific inquiry, the nature of science, and the interrelationship between science, technology, and society. Extensions involve researching Dorothy Crowfoot Hodgkin and Glenn T. Seaborg. An Off the Beaten Path section offers chemistry facts to stimulate creative thinking. References provide additional information and teaching materials. (Author/JG) ENC-019721

Ordering Information
Discovery Channel School / Discovery Communications Inc., PO Box 6027, Florence, KY 41022
Fax: (859) 727-8918 / Toll-free: (888) 892-3484
www.discoveryschool.com
$14.95 per teacher's resource book (paperback)

Chemistry Experiments You Can Do at Home

http://library.thinkquest.org/2690/exper/exper.htm
Series: HyperChemistry on the Web!
Grades 6-12
2001
Contributor(s): ThinkQuest

This web site hosts a variety of chemistry experiments that students can do at home with adult supervision. Topics include gases, reactions with oxygen, and solutions, as well as quantitative tests for substances. A series of miscellaneous experiments explores such topics as surface tension, sublimation, and chemical reaction rates with respect to temperature and surface area. In a sample experiment, students use balloons to compare the size of helium molecules with the size of molecules in room air. Students also examine the role of temperature in solubility and conduct a simple test to determine what foods contain vitamin C. Each experiment includes a problem that states the question being asked, a list of required materials, and a step-by-step procedure. Also part of each experiment are tips on what to observe during the experiment and an explanation of the chemistry concepts involved. Some experiments have an advanced discussion section that explains in greater depth the chemistry behind the experiment. (Author/LCT) ENC-019105

Chemistry Lessons

www.eecs.umich.edu/~coalitn/sciedoutreach/funexperiments/agesubject/chemistry.html
Grades 1-12
1999
Contributor(s): Southeastern Michigan Math-Science Learning Coalition
Publisher: University of Michigan

The chemistry lessons and activities on this web site can be done at home or in a classroom. The site, a product of the Learning Coalition, provides students with hands-on and discovery-based learning experiences promoting scientific and mathematical literacy. Also available on the site are opportunities for students to explore careers within science, mathematics, technology, and engineering fields. The collection of chemistry lesson plans was submitted by many different Coalition partners. Visitors are encouraged to submit their own lessons and experiments via email. Each lesson provides guiding questions, key concepts, and procedures, in addition to materials, extension ideas, and additional resources. Most of the lessons also include research related to the lesson, links to online database or photo archives, and links to sites that identify careers associated with the lesson. In a sample activity, students determine whether common kitchen substances are acids or bases, using cabbage juice as an indicator. The site also provides a link to the Coalition homepage, where visitors can find an alphabetical list of lessons as well as other science lessons organized by subjects or age group. (Author/YK) ENC-017471

Chemistry: Atoms and Elements

Series: Science Workshop Series
Grades 6-12
2000
Contributor(s): Seymour Rosen

This student book and teacher's guide, part of the Science Workshop Series, introduces students to basic chemistry concepts, such as states of matter, atoms and elements, and compounds. The series consists of 12 workbooks that provide a basic secondary school science program for students achieving below grade level. Each workbook has approximately 30 lessons to increase the student's level of competency in science and verbal skills. This unit provides the foundation for student understanding of basic chemistry as it defines terms such as gas, element, and isomer. One lesson about the arrangement of electrons in atoms begins by explaining that scientists previously believed electrons circled the nucleus the same way the planets circled the sun. It then presents the theory that describes the electrons as being arranged in energy shells. Students use diagrams to answer questions about atoms such as sulfur, neon, and hydrogen. In addition, students complete a table by filling in the number of electrons in each shell and determining if the outer shell is complete. At the back of the book are a copy of the periodic table of elements and a table with metric system information. The teacher's edition provides teaching strategies and answers to problems posed in the student edition. A glossary is included with the index. (Author/JR) ENC-018508

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Globe Fearon, PO Box 2500, Lebanon, IN 46052
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www.pearsonlearning.com
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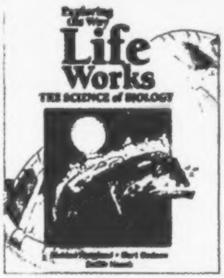
$14.95 per studnet book (paperback)

Exploring the Way Life Works

Grades 9-12
2001
Contributor(s): Bert Dodson, Judy Hauck, and Mahlon Hoagland
Publisher: Jones and Bartlett Publishers



High school biology students can use this textbook to gain an introduction to topics such as the mechanisms of energy production in the cell, the basics of genetic material, and evolution. The book is organized around one central idea: the unity that underlies biological diversity. This tenet is introduced in the first chapter, and the following chapters emphasize broad unifying themes and illustrate these themes with specific cases. The chapters contain numerous Doing Science sections, which summarize current and historically interesting research papers. Tools of Science sections describe classic and current research tools and technologies. Each chapter provides a list of vocabulary words, end-of-chapter questions, and references for further reading. The book also provides cross-references to its companion web site for further exploration of the topics presented in the chapters. A glossary is provided. (Author/FCM) ENC-019235

Ordering Information
Jones and Bartlett Publishers, 40 Tall Pine Drive, Sudbury, MA 01776
(978) 443-5000 / Fax: (978) 443-8000
www.jbpub.com
$47.95 per book (paperback)

Fundamentals of General, Organic and Biological Chemistry

Grades 9 and up
1999
Contributor(s): John McMurry and Mary E. Castellion

This third-edition textbook provides an introduction to chemistry and how it applies to living things. The book emphasizes relevancy, problem solving, and spatial visualization as well as the connections that exist between general, organic, and biological chemistry concepts. Applications boxes provide real-world examples, and concept-link icons indicate previously covered material that is relevant to the current study. There are also multiple solved problems that demonstrate step-by-step strategies for answering common types of chemistry questions. Color photographs, diagrams, and tables support the text, along with practice problems and chapter summary paragraphs. A sample chapter, Amino Acids and Proteins, investigates the chemical basis of life. The chapter addresses structure and function of each type of molecule, along with the dependence of acid-base properties on the cellular environment. A Connections page features Linnea Hallberg, a food technologist, who explores new methods of food processing and packaging. In the Applications section, the importance of good nutrition in fighting disease is addressed. Key terms with definitions are located in the margins as they are presented in the reading. (Author/JG) ENC-020464

Ordering Information
Prentice Hall School Division, PO Box 2500, Lebanon, IN 46052
Fax: (877) 260-2530 / Toll-free: (800) 848-9500
www.phschool.com
$105.00 per book (hardbound)

The Home and School Science Activity Book: Matter

Grades 4-12
2000
Contributor(s): Bernie Horvath and Kevin Horvath

Using everyday language, this book explains physical science principles and can be used as an interactive tool by parents and teachers. The text is organized into sections that contain questions, answers with explanations, and experiments that use home materials to explore the concepts of atoms and molecules. The authors' goal is to correct common misconceptions about science and to show that magic tricks have a science foundation. Black-and-white diagrams illustrate how to perform the experiments; charts and an invention timeline offer additional information. A sample section, Facts of the Matter, addresses the question of what matter really is. A Balloon Scale activity demonstrates that air is matter because a blown-up balloon is heavier than a deflated balloon. Other experiments involve predicting and testing what will happen to the volume of one cup of water when it is poured into a glass, a bowl, and a frying pan. The different types of matter are described to help connect hands-on components with the questions at hand. After the section is completed, readers learn that matter takes up space, has mass, and can be classified into solids, liquids, and gases depending on its properties. (Author/JG) ENC-020102

Ordering Information
Pigeon Press, Suite 8, 6005 West 128th Street, Overland Park, KS 66209
(812) 283-4921 / Fax: (812) 283-8769
home.earthlink.net/~kgrizwald/index2.html
$11.50 per activity book (spiral-bound)

WebElements: Scholar Edition

www.webelements.com/webelements/scholar/index.html
Grades 8-12
2001
Contributor(s): Mark J. Winter
Publisher: WebElements Ltd UK

This interactive web site provides information about elements and the properties of the periodic table. Users click on elements in the table to explore their properties. Brief audio descriptions of elements and examples of their pronunciations are provided. Color graphs, computer-generated figures, and photographs illustrate the site. A menu bar across the top of the page includes an index of online chemistry resources and interactive chemistry calculators. Menus also allow users to select pictorial representations of various properties of elements in the periodic table, such as electronegativity, atomic radius, and element-to-element distance. As an example, clicking on the symbol for hydrogen brings up facts concerning hydrogen's structure and uses. Descriptions of hydrogen compounds and examples of where hydrogen is found in the biological and geological world are also featured. Special software is required to run certain programs. (Author/LEB) ENC-021026

Earth, Space, and Environmental Science

All About Water Ecosystems

Series: Ecosystems for Children
Grades K-4
2001
Contributor(s): Jeffrey Hinman, Andrew Schlessinger, Tracy Mitchell, Conrad M. Follmer, Jason Williams, William Morgan, Allan Butler, and Lisa Feit
Publisher: Schlessinger Media

Developed as part of the Ecosystems for Children series, this video explores both freshwater and saltwater ecosystems. Each 23-minute video in this 3-volume set presents the components of an ecosystem, includes a visit with an expert in the field, and demonstrates a hands-on activity that can be simulated in the classroom. Students are encouraged to construct an understanding of biological concepts through this video's investigation of the life cycles of plants and animals, their habitats, and how their interactions affect one another. A teacher's guide features a program summary, a glossary, and discussion points to use before and after viewing the video. A portion of this program portrays students working with a female marine biologist who studies oysters in the Chesapeake Bay. She explains to the students that scientists study the health of oysters to determine the quality of water in which they reside. In another program segment, an experiment demonstrates the effects of pollutants--such as laundry detergent, fertilizer, and vegetable oil--on pond water ecosystems. In the experiment, students place a spoonful of algae into jars containing each of these pollutants, as well as into a jar of unpolluted pond water. Students then prepare slides of each of the variables and analyze them under a microscope. (Author/TMH) ENC-020812

Ordering Information
Library Video Company, 7 E. Wynnewood Road, PO Box 580, Wynnewood, PA 19096
(610) 645-4000 / Fax: (610) 645-4040 / Toll-free: (800) 843-3620
www.libraryvideo.com
$29.95 per video with teacher's guide

The Changing Earth

Series: Exploring the Earth
Grades 2-3
2002
Contributor(s): Rebecca Olien
Publisher: Bridgestone Books

Part of the Exploring the Earth series, this book describes the structure of the Earth and its changing nature. In this book, full-color photographs and diagrams illustrate concepts such as mountain building, earthquakes, and volcanism. Students engage in an activity in which they add drops of food coloring to a mixture of cornstarch and water to simulate the interaction of hot magma with the Earth's mantle. Also included is a glossary of Earth science terms, a reference list for further reading, and a list of relevant web sites. (Author/GAB) ENC-020936

Ordering Information
Capstone Press, 151 Good Counsel Drive, PO Box 669, Mankato, MN 56002
(507) 388-6650 / Fax: (888) 262-0705 / Toll-free: (800) 747-4992
www.capstone-press.com
$13.95 per book (hardbound)

Climate and Seasons

Series: Weather Fundamentals
Grades 4-7
1998
Contributor(s): Andrew Schlessinger, Gail Prensky, Jason Williams, Kathleen McHale, Leslie Donnelly, Richard Craig, Trish Mitchell, and William Morgan
Publisher: Schlessinger Media

In this video program, viewers learn about the world's climates and the rhythm of the seasons. The program explores how factors such as the sun, wind, and position of the Earth determine a region's weather. The video is part of a series designed to help students understand the science behind weather phenomena, from the formation of a rain droplet to the development of a tornado's vortex. Each program features live-action footage and detailed weather maps, as well as hands-on experiments in which students learn how to observe and think about weather. This video illustrates how the tilt of the Earth's axis and its relationship to the sun affect the seasons. It examines how temperature changes in the Florida Keys affect the coral reefs there and explains how an erupting volcano affects weather conditions throughout the world. In a featured science experiment, students recreate convection currents in water to understand how similar currents in the atmosphere cause wind and weather changes. The program also addresses climate issues such as global warming and El Nino. The accompanying teacher's guide provides teachers with a summary of the program along with vocabulary words, previewing and discussion questions, and suggestions for follow-up activities. Sample activities have students list the characteristics of weather versus climate on a chart and label the Earth's major climate zones on a map of the world. (Author/YK) ENC-016125

Ordering Information
Library Video Company, 7 E. Wynnewood Road, PO Box 580, Wynnewood, PA 19096
(610) 645-4000 / Fax: (610) 645-4040 / Toll-free: (800) 843-3620
www.libraryvideo.com
$39.95 per videotape
$239.70 per 6 video set (teacher's guide included)

Earth

Series: The Galaxy
Grades 2-3
2000
Contributor(s): Steven L. Kipp
Publisher: Bridgestone Books

Each book in The Galaxy series studies one of the 9 planets of our solar system; in this volume, the subject is the planet Earth. Topics include Earth's location in space, atmospheric composition, and geologic layers. The text also highlights phenomena such as continental drift and rotation on an imaginary axis. Full-page color photographs support the text along with diagrams, Fast Facts, and a glossary of key terms. (Author/JG) ENC-021022

Ordering Information
Capstone Press, 151 Good Counsel Drive, PO Box 669, Mankato, MN 56002
(507) 388-6650 / Fax: (888) 262-0705 / Toll-free: (800) 747-4992
www.capstone-press.com
$13.95 per book (hardbound)

Energy Resources

Series: Energy in Action
Grades 5-8
2000
Contributor(s): David H. Gluck, Andrew Schlessinger, Tracy Mitchell, Conrad M. Follmer, Deborah C. Hoard, and Kate Youngdahl
Publisher: Schlessinger Media

The after-school exploits of an aspiring assistant scientist, shown on this short video, introduce the topics of energy resources and conservation. The program focuses on the decreasing supply of fossil fuels and possible solutions to this problem, such as alternative energy sources and energy conservation. A teacher's guide is included that contains warm-up questions, focus questions, and ideas for discussion after the video, as well as follow-up activities and a glossary of energy conservation terms. Also introduced in this video is a brief history of energy consumption, including the effects of the industrial revolution. The program addresses alternative energy sources, such as solar, wind, and biomass power. One follow-up activity in the teacher's guide suggests having students role-play the delivery of a persuasive speech to city council in favor of energy conservation. (Author/GAB) ENC-020813

Ordering Information
Library Video Company, 7 E. Wynnewood Road, PO Box 580, Wynnewood, PA 19096
(610) 645-4000 / Fax: (610) 645-4040 / Toll-free: (800) 843-3620
www.libraryvideo.com
$39.95 per video with teacher's guide

Environmental Science

Grades 11 and up
2001
Contributor(s): Daniel D. Chiras

This environmental science textbook introduces students to the fundamental causes of environmental problems and presents solutions based on systemic reform. Centered around six key themes, including scientific principles, sustainability, and critical thinking, the text emphasizes the critical nature of ecological balance and the role that humans must play in maintaining this balance. Color photographs, diagrams, and maps are found throughout each chapter, along with review questions and Spotlight sections that describe real-world applications of learned concepts. A sample chapter, Population: Measuring Growth and Its Impact, discusses the impact of rapid population growth on the Earth's carrying capacity. Graphs display the growth curve from the Old Stone Age to Modern Times, the infant mortality decline in the United States from 1915 to 1997, and the relationship between total fertility rate and economic health. Population histograms are also presented that compare and contrast expansive, constrictive, and stationary populations. The Spotlight story features Thailand's national population policy that promotes public education and family planning programs. (Author/JG) ENC-020572

Ordering Information
Jones and Bartlett Publishers, 40 Tall Pine Drive, Sudbury, MA 01776
(978) 443-5000 / Fax: (978) 443-8000
$84.95 per book (hardbound)

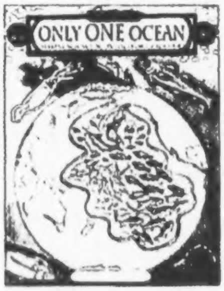
NOVA: Hot Science

www.pbs.org/wgbh/nova/hotscience/
Series: NOVA Online
Grades: 6 and up
2002
Contributor(s): WGBH (Boston, MA) Science Unit
Publisher: PBS Online

Maintained by the PBS series NOVA, this web site is a categorized, annotated list of links to interactive NOVA sites. Each annotation provides a description of the site and indicates what plug-ins, if any, are required. Categories range from the human body to Earth science to engineering. At one site, which requires a shockwave plug-in, visitors can step into the shoes of the man who made a record-setting skydive jump from 100,000 feet. At another site, shockwave is again used to give visitors the chance to build a Roman aqueduct. Other activities involve virtual transplantation of a human heart, exploration of DNA strands, and the examination a New England house to monitor energy consumption. (Author/GAB) ENC-021030

Only One Ocean: Grades 5-8

Series: GEMS. MARE.
2001
Contributor(s): Catherine Halversen, Craig Strang, and Kimi Hosoume



This Great Explorations in Math and Science (GEMS) teacher's guide features three hands-on activities that explore the ocean's impact on life on Earth. Exercises are adapted from the Marine Activities, Resources and Education (MARE) program--a whole-school, interdisciplinary, marine science course bridging science content with activities that promote language development. Lesson plans are sequenced to develop main concepts in the Earth and life sciences, as well as to provide opportunities for students to make learning discoveries and connections to the material. Labs are designed to follow the NSES. Reproducible student worksheets are included. Each activity provides teachers with an overview of the lesson, a list of materials, and lab preparation steps. Also included are methods to help students recall what they already know about the subject, experiences to build on their prior knowledge, and lesson extensions. Teaching strategies and sidebars are featured as well. In a sample activity, students enjoy a seafood smorgasbord and then work in small groups to discuss the overexploitation of ocean resources by commercial fishing operations. Students then offer recommendations for managing fisheries in a sustainable way at a mock World Fisheries Conference. Appendices include student and teacher resources, assessment suggestions, and literature connections, in addition to summary outlines of each activity. (Author/LEB) ENC-020781

Ordering Information
GEMS - Great Explorations in Math and Science, University of California, Berkeley, Lawrence Hall of Science #5200, Berkeley, CA 94720
(510) 642-7771 / Fax: (510) 643-0309
www.lhs.berkeley.edu/gems/GEMS.html
$16.00 per teacher's guide (paperback)

Planet Earth

Series: PrimeTime Library
Grades 3-6
1992
Contributor(s): Columbus Public Schools (OH) ABE Staff

Part of the PrimeTime Library series, this book and audio cassette feature seven short stories with an environmental focus. The set is part of a series that presents fiction and nonfiction titles on themes, including the environment, science, and health. In this book, entries range from one writer's story of how he helped protect the wild mustangs of Nevada, to an account of a father and son investigating the life cycle of dung beetles. The cassette tape features narration of the readings in the book. (Author/GAB) ENC-021218

Ordering Information
Essential Learning Products, 3880 Zane Trace Drive, PO Box 2590, Columbus, OH 43228
(614) 486-0633 / Fax: (614) 487-2272 / Toll-free: (800) 357-3570
www.elp-web.com
$1.95 per book (paperback)
$4.95 per book and cassette

Sunflower/Girasol Air Unit

Series: Sunflower Science Discovery Curriculum for Children
Grades 2-6
1998
Contributor(s): Intercultural Center for Research in Education, Inc.

Six cartoon kids featured in this activity book present hands-on explorations focused on the subject of air. The book and accompanying teacher's guide are part of a fully bilingual English/Spanish curriculum designed to encourage Latino students to develop language and scientific skills. In this unit, each activity begins with full-color illustrations that depict the six characters and their pets as they interact with their teacher and each other to introduce background information for the activity. Each exploration also contains a list of materials, a procedure, and questions for discussion. The teacher's guide provides teaching suggestions as well as extension activities. In one activity, "A year's worth of air," Juan wonders aloud how many times a person breathes in a year. The teacher's guide suggests that teachers use a model of the human respiratory system to stimulate a preliminary class discussion about breathing. In the exploration, students count how many breaths they take in a minute. Calculators are then used to come up with an estimate for the number of breaths in a year. Students can mail their estimates to the curriculum producers to receive a small gift from Natalia's cat, Misifu; their data is also posted on the Sunflower/Girasol web site. In another extension activity, students estimate how much air is in one breath. (Author/GAB) ENC-021220

Ordering Information
Intercultural Center for Research in Education (INCRE), 366 Massachusetts Avenue, Arlington, MA 02474
(781) 643-2142 / Fax: (781) 643-1315 / Toll-free: (888) 462-7374
www.incre.org
$79.00 per classroom set
$10.00 per teacher's guide (spiral-bound)
$5.00 per student workbook (paperback)

SpaceKids

spacekids.hq.nasa.gov
Grades 3-8
2001
Contributor(s): George Varros and John Lee
Publisher: National Aeronautics and Space Administration (NASA)

At this NASA web site, students can explore space science topics such as the coronal mass ejections of the sun, Earth's magnetosphere, and auroras. The site also contains current NASA press releases and pictures from several NASA missions. Visitors can choose to include their names on a CD to be sent to Mars on the Mars Exploration Rover 2003 mission. Also included are images of solar activity and information about amateur astronomy. (Author/FCM) ENC-020185

Star Factories

Series: Turnstone Space Explorer
Grades 6-8
2001
Contributor(s): Ray Jayawardhana

STAR FACTORIES

Part of the Turnstone Space Explorer series on astronomy, this book introduces the formation of stars and planets using full-color photographs, illustrations, and diagrams. The book presents clues used by scientists to study star and planet formation, including dust disks and asteroids. The text also addresses the use of different wavelengths of light in astronomical observation and scientists' use of models, such as in theories of the formation of the moon. Various types of telescopes throughout the world are described based on the wavelength of light collected. Historical notes are also presented highlighting key astronomers and their evolving understanding of the genesis of these celestial objects. (Author/GAB) ENC-019993

Ordering Information
Steck-Vaughn Company, PO Box 690789, Orlando, FL 32819
Fax: (800) 699-9459 / Toll-free: (800) 531-5015
www.steck-vaughn.com
$8.75 per book (paperback)

Understanding Your Environment

Series: EarthComm: Earth System Science in the Community
Grades 9-12
2001
Contributor(s): John B. Southard, Michael J. Smith, Emily Crum, and Ruta Demery

This curriculum unit provides an in-depth study of bedrock geology, river systems, and land-use planning. Each unit of this five-part series emphasizes the principles and practices of Earth science while demonstrating how these topics affect life on Earth. The teacher's edition contains all of the information found in the student textbook as well as an overview, student goals, and chapter timelines. The guide also features a one-page layout of how each topic within the chapter correlates with the NSES. Each chapter in the student book presents a Scenario, Challenge, and listing of Assessment Criteria along with several activities that supplement the featured topic. For example, in the chapter Bedrock Geology...and Your Community, the Scenario discusses how one community's Bed and Breakfast Association wants to provide guests with geologic information about the place they are visiting. The Challenge requires students to write a report for the association about the geologic history of the community, including information about the highways, hiking trails, and parks. An accompanying activity requires students to analyze a geologic map and cross-section of Georgia and Alabama to answer questions about the formation, deposition, and arrangement of the rocks located in those areas. (Author/TMH) ENC-021217

Ordering Information
IT'S ABOUT TIME Inc., Suite 307, 84 Business Park Drive, Armonk, NY 10504
Fax: (914) 273-2227 / Toll-free: (888) 698-8463
www.its-about-time.com
$19.95 per student
$39.95 per teacher edition

Waste in Place

Grades K-6
1997
Contributor(s): Keep America Beautiful, Inc.

The 36 activities in this curriculum guide are designed to educate students about the sources of municipal waste, the characteristics of this waste, and the various options for handling it. The guide advocates an attitude-change process that promotes factual knowledge, community involvement, and a focus on results. Topics include litter prevention, waste reduction, and recycling, as well as composting and landfills. Background information is provided, along with a glossary of key terms and suggestions for interdisciplinary implementation. A sample section, Recycling and Composting, asks students to simulate separation techniques commonly used by materials recovery facilities, such as blowing paper and plastic or puffing out ferrous metals with magnets. A discussion of the difference between preconsumer and postconsumer waste is followed by an investigation into the meaning of plastic identification codes. Students circle around a pile of plastic containers and determine how the properties of each container relate to the given code. An extension activity includes surveying plastics at home and calculating the percentage of each code type. (Author/JG) ENC-019302

Ordering Information
Keep America Beautiful, Inc., Washington Square, 1010 Washington Blvd, Stamford, CT 06901
(203) 323-8987 / Fax: (203) 325-9199
www.kab.org
$40.00 per curriculum guide (loose-leaf)

WISE, the Web-Based Inquiry Science Environment

wise.berkeley.edu/welcome.php
Series: Web-Based Inquiry Science Environment (WISE).
Grades 4-12
2001
Contributor(s): Jim Slotta and Marcia Linn
Publisher: University of California, Berkeley

More than an online learning community, the Web-based Inquiry Science Environment (WISE) provides an opportunity for students to analyze current scientific controversies using real-world evidence. WISE is a research project that collects data from its users to investigate teachers' and scientists' beliefs about technology and the Internet. The data are also used to discern the best ways to support WISE community members as they prepare to use WISE projects and author WISE curricula. WISE projects are designed to complement coursework and to meet the NSES. Each WISE project is divided into several main activities, which are further broken down into inquiry steps. As an example, one project highlights the controversy surrounding the control of malaria. In the first activity, students learn about the relationship between malaria, mosquitoes, and climate. This understanding is refined in the second activity, during which students learn about the life cycles of the malaria parasite and mosquitoes. Finally, students compare three different strategies of controlling the spread of malaria in an online discussion. Online membership is required to participate. (Author/LEB) ENC-020922

Life Science and Biology

Biology Lessons

www.eecs.umich.edu/~coalitn/sciedoutreach/funexperiments/agesubject/biology.html
Grades 1-12
1999
Contributor(s): Southeastern Michigan Math-Science Learning Coalition
Publisher: University of Michigan, Electrical Engineering and Computer Science

This web site, maintained by the Southeastern Michigan Math-Science Learning Coalition, contains links to biology lesson plans organized by grade level. Submitted by different coalition partners, the lessons range from physiology and health to diversity and ecology. Each lesson identifies its author and origin. One of the lessons, Mushroom Prints, asks students to cover a mushroom cap with a bowl on a piece of paper. The students discuss the physiology and life cycle of a fungus. The lesson concepts and facts are listed, and a glossary defines the scientific terms. The lesson identifies careers related to the lesson, and extension activities are suggested. (Author/JR) ENC-017384

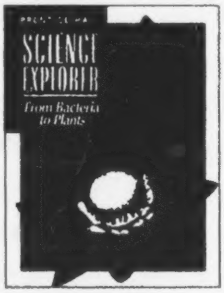
Evolution

www.pbs.org/wgbh/evolution/index.html
Grades 6 and up
2001
Contributor(s): Liz Carver, Peter Ross, Richard Hutton, Sharon Broder, and Susan K. Lewis
Publisher: PBS Online

Part of the evolution project produced by PBS, this web site offers content knowledge on evolution to accompany an educational initiative, TV series, and companion book. Topics include biographical information about Darwin and his revolutionary idea, mass extinction, and the diverse tree of life. Additional sections address interactions between and among organisms that ensure survival, genetic variation arising from sexual reproduction, and the origin of humankind. The site also considers how to reconcile evolution and faith. An online professional development course is offered for teachers, and there are lessons available for students. The course features simulations, interactive activities, expert roundtable discussions, and seven short videos. In a sample section, students explore the principle of natural selection through a simulation of bacteria insufficiently treated with antibiotics. The simulation demonstrates how resistant bacteria arise in such short periods of time. A downloadable PDF version of a teacher's guide provides student activities and background resources. Special software is required for certain programs and downloads. (Author/LEB) ENC-020667

From Bacteria to Plants

Series: Prentice Hall Science Explorer
Grades 6-9
2000
Contributor(s): Evan P. Silberstein, James Robert Kaczynski Jr., Jan Jenner, and Joseph Stukey



This kit introduces students to life science through a focus on microorganisms and plants. Each kit in the 15-part series consists of a textbook, a teacher resource book, and a student tutorial on CD-ROM, as well as a guided reading audiotape summarizing the chapters in the text. The teacher's edition of the textbook provides detailed references to the NSES and AAAS benchmarks. Also included are sidebars on interdisciplinary extensions and background information, such as historical notes, lab safety issues, and additional technology resources. End-of-chapter review questions offer exercises, such as completing concept maps and tables, as well as critical thinking questions for small-group discussion. In this kit, a chapter on protists and fungi includes a long-term project during which students design a mushroom farm. Short, hands-on activities include investigating the various types of life present in a drop of pond water and observing the effect of algae growth on pond life. Medium-length activities highlight a specific skill or real-world application, such as drawing conclusions on the effect sugar and salt have on yeast activity. The teacher resource book contains blackline masters of the project and activity worksheets, as well as full-color transparencies. The student tutorial CD-ROM provides section summaries and explorations, such as an interactive exercise on identifying the structures of a paramecium. Also included on the CD are supplemental multiple-choice self-tests for each section in the chapter. (Author/GAB) ENC-020264

Ordering Information
Prentice Hall School Division, PO Box 2500, Lebanon, IN 46052
Fax: (877) 260-2530 / Toll-free: (800) 848-9500
www.phschool.com
$12.47 per student text (hardbound)
$31.47 per teacher's edition (hardbound)
$129.47 per teacher's kit

Great Feuds in Medicine

Grades 9 and up
2001
Contributor(s): Hal Hellman

The author of this book describes 10 disputes identified as the liveliest controversies of medical history. The text ranges from the debate regarding William Harvey's theory of blood circulation in the 17th century to the recent dispute between American Robert Gallo and French researcher Luc Montagnier over the discovery of HIV. Controversies were selected based on their degree of drama or scientific interest. The debates' influence over the course of medical science and their present-day repercussions were also considered. Quotations from various sides of the issues are interspersed throughout. The disputes are presented in chronological order. In a highlighted section, obstetrician Ignaz Philipp Semmelweis ignites a controversy by making the recommendation to his staff that they aggressively wash their hands before performing internal examinations of postpartum women. The suggestion emanated from Semmelweis's observation that a difference in death rate existed between clinics of his hospital. A far higher death rate existed in the clinic where training physicians who spent part of their day dissecting cadavers later examined patients. Semmelweis's recommendation resulted from his theory that poisoned cadaveric material was transferred to the victims' vascular system. Appendices include notes and references for each chapter. (Author/LEB) ENC-020642

Ordering Information
John Wiley and Sons, Inc., One Wiley Drive, Somerset, NJ 08875
(908) 469-4400 / Fax: (732) 302-2300 / Toll-free: (800) 225-5945
www.wiley.com
$24.95 per book (hardbound)

Hidden Worlds

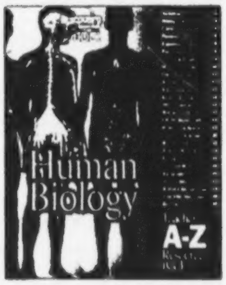
Series: Scientists in the Field
Grades 4-7
2001
Contributor(s): Dennis Kunkel and Stephen P. Kramer

Readers of this book learn how microscopist Dennis Kunkel, Ph.D., became interested in science, how he prepares specimens, and how different microscopes work. The text also follows Kunkel as he collects samples in the field, from the ash of Mount St. Helens to the rainforests of Hawaii. Black-and-white and color images display a multitude of objects at various magnifications, including a carpet beetle, a myoblast, and a blade of grass. A sample section tells the story of a biologist attacked by a box jellyfish near Waikiki Beach. After her recovery, she enlisted the aid of Dr. Kunkel to study how the jellyfish injects venom into its prey. Magnifications revealed triangular-shaped spines, which may play a role in the process. Kunkel's other scientific collaborations involve working with young students on their science fair projects and exploring Hawaii Volcanoes National Park with his wife, a fellow scientist. (Author/JG) ENC-020875

Ordering Information
Houghton Mifflin Trade and Reference Division, A Houghton Mifflin Company, 181 Ballardvale Street, Wilmington, MA 01887
(978) 661-1300 / Fax: (800) 634-7568 / Toll-free: (800) 225-3362
www.hmco.com
$16.00 per book (hardbound)

Human Biology

Series: Teachers A-Z Resource Books
Grades 5-9
2000
Contributor(s): Stephen M. Tomecek



This resource guide provides science teachers and students with 32 pages of classroom tools for studying the human body. Organized alphabetically from Activities to Zingers, each section offers a different perspective on human biological processes. Demonstrations, Just For Fun, and Science Projects contain hands-on investigations, while a Careers page illustrates how biological science is used in the real world. Black-and-white photographs and reproducible student worksheets support the text along with an icon-based navigational system that assists readers in locating specific types of materials. In a sample chapter, students research Egyptian mummification and observe the different ways in which famous artists, such as Michaelangelo and Picasso, represent human form. References to the NSES emphasize how cross-curricular connections can add new dimensions to learning science. Additional integrations involve calculating arm and leg ratios and writing an essay about the relationship between body systems and physical activity. There is also a section devoted to clarifying common misconceptions about endorphins and white blood cells. References are provided. (Author/JG) ENC-019809

Ordering Information
Discovery Channel School / Discovery Communications Inc., PO Box 6027, Florence, KY 41022
Fax: (859) 727-8918 / Toll-free: (888) 892-3484
www.discoveryschool.com
$14.95 per teacher's resource book (paperback)

Learning Programs for Biology

ebiomedia.com
Grades 9 and up
2001
Contributor(s): BioMedia Associates

This web site offers numerous photographs and animations of biological organisms accompanied by informative text. A monthly contest challenges viewers to identify an organism from a photo posted on the site. Several quizzes containing similar questions are also included. The gallery section provides a collection of photographs accompanied by text. The collections include evolution of the eye, rotifers, and larvae of various marine animals. The teacher's section provides teaching guides for the products of the Biomedia Associates as well as discussion papers on multimedia techniques, free educational software, and short, single-concept QuickTime movies. Annotated Web Link Sets on biology topics and concepts can be used as starting points for study or for online research projects. (Author/FCM) ENC-019691

Patterns of Nature

Series: Life by the Numbers
Grades 7-12
1998
Contributor(s): David Elisco, Gregory Andorfer, Janet Driscoll Smith, Joe Seamans, and Mark Knobil
Publisher: WQED

This video explains how giant locusts and other favorites of horror movies are not possible, as the weight/size ratios would not be sustainable. The program also considers how leopards get their spots and investigates the relationship between DNA and mathematical knot theory. The Life by the Numbers series offers seven hour-long videos that explore some aspects of modern life that have mathematics at their core, such as sports, technology, and space exploration. This video has five program segments that include the use of fractal geometry, the rule of self-similarity, and a computer to describe and model the complex form of a flower and other natural structures. Program segments focus on using mathematics to explain complex biological ideas. Highlights include the work of an evolutionary biologist who creates a virtual rainforest using mathematics, and who examines the process of evolution using a computer model. A free teaching guide features four-page spreads for each video that include classroom activities based on the program segments, thematic overviews, and mathematical background information on key concepts. The guide includes a description of a school math trail with activities geared to locations likely to be found in most schools. Students work with proportion and scale, the tangent function, slope, and patterns and fractals while answering questions related to their school. The goal is to help students see the mathematics in their world. All activities in the teaching guide can be used independently or to support classroom use of the videotapes. (Author/JRS) ENC-014171

Ordering Information
Monterey Media, 566 St. Charles Drive, Thousand Oaks, CA 91360
Fax: (805) 496-6061 / Toll-free: (800) 424-2593
www.wqed.org
$120.00 per series (7 videotapes)
$19.95 per video

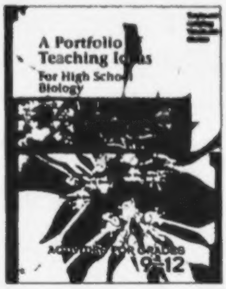
Plants and Animals

educate.si.edu/resources/lessons/siyc/pollen/start.html
Series: Smithsonian in Your Classroom.
Grades 4-9
2001
Contributor(s): Lydia Paddock, Alan Smigielski, and Sarita Rodriguez
Publisher: Smithsonian Center for Education and Museum Studies

Take a closer look at the pollination process with this online Smithsonian unit, which comprises three lessons that explore the theme of plant and animal interaction during the process. The unit includes background information about pollination and activities and their accompanying worksheets, along with resources for more information on the subject. Lessons are also available in PDF format for downloading. Each activity provides objectives, materials, and related subjects, in addition to a step-by-step procedure. A highlighted lesson requires students to identify plant and animal parts involved in the plant reproduction process. Students also demonstrate how pollen is transferred from male to female plants in a kinesthetic activity. The lesson includes diagrams of a plant and a bee, along with questions for students to answer. (Author/LEB) ENC-021012

A Portfolio of Teaching Ideas for High School Biology

Series: Teachers Helping Teachers
Grades 9-12
1996
Contributor(s): Don Galbraith



The 36 biology problem-solving activities in this book involve everyday situations and scenarios. The book is part of a series that features the collaborative ideas teachers generated at workshops to improve teaching. It covers a variety of teaching topics, such as genetics, plants, and animal physiology, presented in a ready to use format. Student exercises include background information for teachers and reproducible student worksheets. One chapter suggests items for inclusion in a student portfolio, along with their corresponding grading rubrics. A sample activity, based on an actual epidemiological investigation conducted in South Dakota, requires students to set up a mock epidemiological study to determine the cause of illness among 1,200 people within a nine-county area. Patient symptoms include shortness of breath, restlessness, and irritability. Blood tests indicate a high level of thyroxin hormone, but the patients do not exhibit enlarged thyroids, as the blood work would seem to indicate. Epidemiological data and questions to direct student thinking are provided to help students solve the medical mystery. Appendices include materials required for highlighted activities and resources for teaching biology. (Author/LEB) ENC-020872

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www.trifoliumbooks.com
$35.95 per book (paperback)

The Structures of Life

Series: NIH Publication
Grades 8 and up
2000
Contributor(s): National Institutes of Health

Created by the National Institutes of Health, this booklet describes cutting-edge structural biology and biomedical research on human health and disease prevention. Each of the book's five chapters contains a set of comprehensive review questions. Three chapters feature the work and thoughts of student researchers. The final section shares the future possibilities of structural biology in contributing to scientific knowledge and technology. Sidebars provide supplemental information to the text, and color figures illustrate biological concepts described in the writing. A chapter on X-ray crystallography, for example, describes one of the two most commonly used methods to study molecular structures. The student featured in this section shares his research of a protein that prevents cells from committing suicide. Findings from his investigations could potentially lead to a further understanding of apoptosis, which scientists hope may be used to treat degenerative nerve diseases. A glossary is included. (Author/LEB) ENC-020467

Ordering Information
National Institutes of Health, Public Information Office, 45 Center Drive MSC 6200, Bethesda, MD 20892
(301) 496-7301 / Fax: (301) 402-0224
$0.00 per book (paperback)

Physics

All About Simple Machines

Series: Physical Science for Children
Grades K-4
2000
Contributor(s): Conrad M. Follmer, Denise Pospisil, Tarquin Cardona, Andrew Schlessinger, Olga Palacio, and Tracy Mitchell
Publisher: Schlessinger Media

Part of the Physical Science for Children series, this video introduces the fundamental physical science principles that shape daily life. From pinwheels and hammer claws to doorknobs and sail hoists, viewers learn that simple machines are found everywhere. The presentation is organized into segments that explain and demonstrate force, work, and the six types of simple machines. Review sessions follow each of these segments to reinforce learned concepts. An accompanying teacher's guide provides focus questions and extension activities. A sample section explains how levers can make work easier. A skit demonstrates how primitive cultures developed a lever system to move large objects, and then the program discusses the parts of a lever. In a follow-up investigation, students with similar weights pair off and work on trying to lift one another off a small stool. This force is compared with the force needed to lift the same person when he or she is sitting on a teeter-totter. An additional investigation challenges students to predict and test what will happen when the person moves toward and away from the fulcrum. Characteristics of compound machines are also addressed. (Author/JG) ENC-020253

Ordering Information
Library Video Company, 7 E. Wynnewood Road, PO Box 580, Wynnewood, PA 19096
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www.libraryvideo.com
$29.95 per video with teacher guide

Changes in Properties of Matter

Series: Physical Science for Children
Grades K-4
2000
Contributor(s): Conrad M. Follmer, Denise Pospisil, Tarquin Cardona, Andrew Schlessinger, Olga Palacio, and Tracy Mitchell
Publisher: Schlessinger Media

In this video program, the hostess and her friends encounter the properties of matter. From motorcycles and rivers to spaghetti and meatballs, viewers learn that matter is found all around them. Topics include the relationship between matter and energy, phase changes, and physical properties. A sample section defines terms such as melting point, boiling point, and vaporization and describes how frozen water can be converted into liquid and then steam. A Lab World investigation follows, which involves confirming the Law of Conservation of Matter. Students compare the masses of vinegar and baking soda before and after the two substances are combined in a plastic bottle. The program provides additional information about the role of sand in making glass and computer chips. (Author/JG) ENC-020215

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www.libraryvideo.com
$39.95 per video with teacher's guide

Far Out Physics

Series: New Explorers
Grades 5-8
2001
Contributor(s): David Stockman, Barry Stoner, Bill Kurtis, Jim Hatfield and Maria Finitzo
Publisher: Electronic Long Distance Learning Network (eld!n)

This interactive multimedia program is part of the ELD!N (Electronic Long Distance Learning Network) curriculum series. Through videos, CD-ROM presentations, and web sites, students learn about topics such as simple machines, Newton's laws of motion, and the scientific method. The unit is divided into exploration, investigation, and application sections. Exploration activities are intended to "hook" students' interest, while investigation experiments refine scientific knowledge. In the applications, students create products based on learned concepts and personal creativity. Teacher supplementary material includes a resource guide that outlines the program's philosophy and a handbook that discusses teaching strategies and other available units for study. Multiple forms of alternative assessment are provided including rubrics for each section and student self-evaluations. In a sample lesson, students watch a video of two high school physics classes as they learn about the practicality of Newton's laws of motion. Throughout the program, two teachers use a variety of instructional methods including acceleration experiments with cars and field trips to a wave pool. Students investigate concepts introduced in the video by designing gravity racers, analyzing collisions, and creating balloon rockets. A supplementary student CD-ROM provides guidance throughout the unit and includes instructions for activities, background information, and additional video illustrations. In the culminating activity, students devise a plan to keep organisms within a space capsule healthy and viable during a space mission. (Author/JG) ENC-020263

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Virtual Learning Systems, 1430 North Meacham Road, Schaumburg, IL 60173
(847) 519-1707 / Fax: (847) 843-1377 / Toll-free: (800) 314-1401
www.virls.com/sys-tmpl/door
$999.00 per module and training
$399.00 per module (windows/macintosh)

Holt Science Spectrum: A Physical Approach

Series: Holt Science Spectrum
Grades 9-12
2001
Contributor(s): John Holman, Ken Dobson, Michael Roberts
Publisher: Holt, Rinehart and Winston, Inc.

This book is the annotated teacher's edition of the Holt Science Spectrum program, a general science course covering chemistry, physics, Earth science, and space science with a focus

on physical science. Each chapter of the teacher's edition begins with a section that shows how to integrate cross-disciplinary subjects such as reading, mathematics, and technology. A planning guide gives a quick overview of print resources, labs, and technology available for the chapter. The annotations for the student text include skill-building tips, teaching tips, and multicultural connections. A section called Misconception Alerts describes common misconceptions that students may have about a topic and provides tips on dispelling them. Other features include alternative assessment strategies, experiments that teachers can demonstrate, and historical perspectives, as well as answers to review questions. The book provides correlations with the NSES and a section on laboratory safety. (Author/FCM) ENC-019252

Ordering Information
Holt, Rinehart and Winston, Inc., 6277 Sea Harbor Drive, Orlando, FL 32887
(407) 345-3800 / Fax: (800) 269-5232 / Toll-free: (800) 225-5425
www.hrw.com
$76.50 per Spanish resources kit
$62.80 per student text (hardbound)
$82.65 per teaching resources kit
$73.35 per teacher's annotated edition (hardbound)

The Home and School Science Activity Book: Physical Science

Series: Home and School Science Activity Book
Grades 4-12
1994
Contributor(s): Bernie Horvath and Kevin Horvath

Using everyday language, this book explains physical science principles and can be used as an interactive tool with parents and teachers. The text is organized into sections that contain questions, answers with explanations, and experiments that use home materials to explore chemistry, physics, and astronomy concepts. Through each investigation, the author's goal is to correct common misconceptions about science and to show that magic tricks have a science foundation. Black-and-white diagrams illustrate how to perform the experiments, while charts and a timeline of inventions offer additional information. A sample section, Inertia, asks readers to answer the question of why a person moves forward when the car they are riding in slows down. A Coin in the Cup activity demonstrates that a coin resting on a cardboard square will remain in position when the square is flicked from underneath it. (The result is the coin falling into a cup below.) A bonus experiment involves predicting and testing what will happen when a penny collides with the bottom row of a stack of pennies. The Law of Inertia is described to help connect the hands-on component with the question at hand. After the section is completed, readers learn that a person moves forward because no force is acting to stop the body. (Author/JG) ENC-020101

Ordering Information
Pigeon Press, Suite B, 6005 West 128th Street, Overland Park, KS 66209
(812) 283-4921 / Fax: (812) 283-8769
home.earthlink.net/~kgrizwald/index2.html
$11.50 per activity book (spiral-bound)

Physical Science

Series: Science in the News
Grades 7-10
2000
Contributor(s): Cable News Network, Inc. (CNN)
Publisher: Holt, Rinehart and Winston (HRW)

The 24 CNN news segments on this video are designed to correlate to subjects in Holt science programs. A teacher's guide provides an overview of each program, suggestions for post-viewing activities, and references for further research. There is also a booklet of reproducible worksheets (with answer keys) that assist students in analyzing and evaluating the information they have viewed. Sample footage follows a reporter as he rides NASA's "Vomit Comet"(a modified Boeing 707) to simulate the effects of apparent weightlessness. The report identifies the parabolic pathway of flight, explains the significance of research in "zero gravity" conditions, and describes the sensations felt by scientists during the 30-second "weightless" drop interval. Extension activities ask students to use graphics and vectors to illustrate how astronauts experience free fall and report on the microgravity research being carried out at the NASA Glenn Research Center. Other segments feature current airbag technology such as Smart Skin Sensors, the development of the Virtual Practice Room for music education, and the principles of angular momentum at work in the Cirque du Soleil. (Author/JG) ENC-019104

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www.hrw.com
$47.15 per set

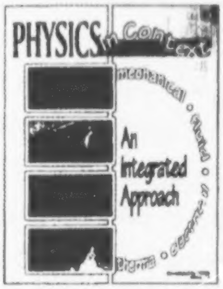
Physics Education

www.iop.org/Journals/pe
Grades 9-12
2001
Contributor(s): Kerry Parker
Publisher: Institute of Physics (IOP)

This web site is the electronic version of the *Physics Education Journal* aimed at providing support and information to high school and undergraduate-level physics teachers. Each issue contains articles written by members of the scientific community, current news topics, and reviews of educational resources. Sample articles from the March 2001 issue include teaching dimensional analysis with trading cards, demonstrating electrical principles with an LCR meter, and determining the contraction coefficient of a free jet of water. A Teaching Notes section suggests pedagogical techniques for teaching difficult concepts while a Signing Off category highlights the lighter, humorous side of physics education. Subscription information, article submission requirements, and archival records are available as well as links to related web sites. Except for current issues, nonsubscribers only have access to the table of contents and abstracts. (Author/JG) ENC-018998

Physics in Context

Grades 9-12
2001
Contributor(s): CORD



This physics textbook and teacher guide are organized within the context of the four energy systems (mechanical, fluid, electrical, and thermal). The teacher's guide contains lecture suggestions and additional explanations of topics with which students may experience difficulty. Also included are activities and demonstrations for introducing new topics, such as using a hand squeeze propagating through a line of people to illustrate thermal conduction. Answers to selected problems are provided in the back of the student version, while solutions to all problems are presented in the teacher's guide. The book requires that students have completed algebra 1, can solve single-variable equations, and can maintain consistency of units in multiplication and division. In a section on energy in mechanical and fluid systems, the teacher's guide suggests beginning with a demonstration in which a student on the floor tosses a ball or beanbag up to a student on a stool or stepladder. The text goes on to define potential energy and the concept of the conservation of energy. Sample problems include making calculations of kinetic and potential energy in the case of a cliff diver. Students encounter Bernoulli's principle through three suggested demonstrations, one of which uses a shop-vac to blow air around a beach ball. Fifteen problems are included at the end of the section, with solutions for each explained in the teacher's guide. (Author/GAB) ENC-020158

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(254) 776-1822 / Fax: (254) 776-3906 / Toll-free: (800) 231-3015
www.educatalog.com
$95.00 per teacher's guide (loose-leaf) in 3 volumes
$49.95 per student book (hardbound)

Physics Matters!

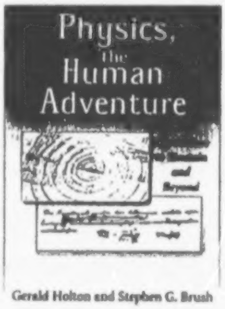
Grades 5-10
2001
Contributor(s): John O. E. Clark

This 10-volume set explains and illustrates the science of physics and its everyday applications. Each volume, devoted to a specific subject, presents topics in self-contained modules. Each module contains a text narrative as well as color photographs and diagrams depicting physics principles, apparatus, and machines. Also included in each module are sidebar biographies of famous physicists as well as cross-references to related entries. At the end of each volume, hands-on activities demonstrate the physics described in the book using step-by-step directions, a materials list, and diagrams of the setup. Each volume also includes a glossary of terms and an index to the entire ten-volume set. In the third volume, *Heat*, one module focuses on the expansion of fluids. Both liquids and gases are examined with respect to expansion under constant pressure. Charles' law is stated nonmathematically in the text with illustrations depicting hot air balloons at various temperatures. Also shown is a drawing of one of the first mechanisms to make use of gas expansion to produce mechanical movement, devised by Hero of Alexandria nearly two thousand years ago. The activity section of this volume contains a related exploration in which a dime dances on the top of a bottle due to expanding air. (Author/GAB) ENC-020093

Ordering Information
Grolier Educational, 90 Sherman Turnpike, Danbury, CT 06816
Fax: (203) 797-3657 / Toll-free: (800) 243-7256
www.publishing.grolier.com
$309.00 per set (10 volumes)

Physics, the Human Adventure

Grade 10 and up
2001
Contributor(s): Gerald Holton and Stephen G. Brush


Physics, the Human Adventure
Gerald Holton and Stephen G. Brush

The third edition of *Introduction to Concepts and Theories in Physical Science* is intended for use in a year-long liberal arts physics course or as a review for individuals preparing to teach physics at the high school or college level. The study of physics is presented within the context of its historical underpinnings, in addition to the more recent advances in research. Interdisciplinary connections are made to chemistry, astronomy, and geoscience. The book emphasizes the nature of discovery, reasoning, and concept formation, as well as theory testing. Found throughout the text are black-and-white photos, illustrations, and mathematical problems as well as tables, graphs, and diagrams. References are provided at the conclusion of each section. A sample chapter describes rotational motion as the motion of an object in a plane and around a center, acted on by a force that continually changes its direction of action. The chapter presents background information and applications of this concept to planetary orbits. Also covered in this section is the work of Jean Richer and Giovanni Domenico Cassini, who measured the centripetal acceleration at two different latitudes using a pendulum in 1672, only to discover that acceleration due to gravity was greater nearer the equator. (Author/LEB) ENC-020147

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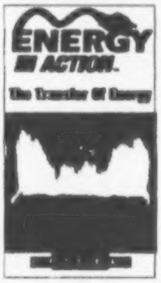
Shedding Light on Science

www.learner.org/channel/workshops/sheddinglight/
Grades K-5
2001
Contributor(s): Anita Greenwood, Camille L. Wainwright, Christine Jones, Lawrence B. Flick, and Sandra K. Abell
Publisher: Annenberg/CPB

Developed by Annenberg/CPB for K-5 teachers, this web site is a professional development tool designed to increase science content knowledge. Organized around an eight-part video series, the site provides a framework for conducting interactive, online workshops and maintaining support networks. Participants partner with a Light Buddy to share ideas, try light activities in their own classrooms, and communicate with participating sites via an online forum. Registration and supplementary materials are free. The set of eight videos uses light as a theme to explore topics in the physical, life, and Earth and space sciences. Viewers learn about the behavior of light and the nature of energy transformations, as well as the role that light plays in weather, seasons, and plant production of food. The web site offers an overview of each program, a glossary of key terms, and links to further information. College credit for the workshop is also available. (Author/JG) ENC-020668

Transfer of Energy

Series: Energy in Action
Grades 5-8
2000
Contributor(s): David H. Gluck, Andrew Schlessinger, Tracy Mitchell, Conrad M. Follmer, and Deborah C. Heard
Publisher: Schlessinger Media



An aspiring assistant scientist capers through this short video to introduce and demonstrate the topic of energy transfer. The video focuses on the transformation of energy from one form to another, giving examples of how this occurs in various aspects of life. This information is relayed to students via a fictitious Professor Z and his inquisitive assistant, the narrator. A teacher's guide contains warm-up questions, focus questions, and ideas for discussion after the video, as well as follow-up activities and a glossary of energy transfer terms. Also introduced in this video is Einstein's law of conservation of mass and energy. Potential and kinetic energy are described as well in several examples including a skier on a hill. The narrator demonstrates kinetic energy transfer by dropping a ping-pong ball together with a golf ball. The golf ball falls below the ping pong ball and transfers its larger kinetic energy during rebound. Also presented is energy transfer from solar energy through photosynthesis to the food chain and humans. One follow-up activity in the teacher's guide suggests having students work in groups to develop their own energy transfer machines using common supplies. (Author/GAB) ENC-020904

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www.libraryvideo.com
$39.95 per video with teacher's guide

Take a Technowalk to Learn About Materials and Structures

Series: Springboards for Teaching
Grades K-8
1997
Contributor(s): Peter Williams, Saryl Jacobson

The 10 exploratory walks outlined in this activity book take children through their local community to investigate the materials and structures found there. The Take a Tehnowalk series covers topics in technology via a walking theme, whereby students can find and investigate examples in their own communities. In this book, each technowalk includes suggested pre- and post-walk activities ranging from class discussions to making models of structures using only one kind of material. Reproducible worksheets include special instructions to accommodate learners at different grade levels. Each technowalk includes background information for the teacher. Extension activities are also given for more advanced or older students. A list of references at the back of the book includes related web sites. In one technowalk, "Going Over," students take a walk to look for and investigate bridges in the local community. Walkers list and draw sketches of the various types of bridges and crossings that they find. The students then research what kinds of materials are used in these bridges and their advantages and disadvantages. In one pre-walk activity, students devise a bridge solution to allow a farmer's cows to cross a two-meter-wide ditch. Extension activities consist of variations on a bridge-building competition. (Author/GAB) ENC-021168

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Integrating the Sciences

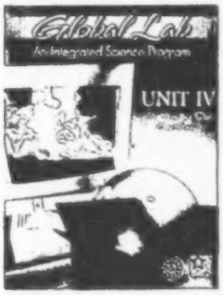
EIA Kids Page

www.eia.doe.gov/kids
Grades 5-8
2001
Contributor(s): United States Department of Energy. Energy Information Administration

Students can use this web site to increase their knowledge about energy issues facing the nation, especially as seen through the eyes of industry. The site provides background information about energy sources, different forms of energy, and energy storage. A colorful icon, the Energy Ant, guides the users through the web site. The Kids' Corner presents interesting stories and biographies of pioneers in energy, including John Dalton, Isaac Newton, and Marie Curie. The Energy Infocard section features statistics on energy production and consumption in the U.S. Also provided are state-specific energy consumption, price, and expenditure estimates. Visitors can read reports of the Energy Ant's field trips to various energy production facilities, including an oil refinery, a nuclear power plant, and a storage facility for liquefied natural gas. The Classroom Connection section provides information about National Energy Education Development's Guidelines for Energy Education and numerous classroom energy activities. An Energy quiz, numerous fun facts, and a list of online resources are also included. (Author/FCM) ENC-020197

Global Lab: Unit 4

Series: Global Lab
Grades 6-9
2001
Contributor(s): Technical Education Research Center Inc.
Publisher: Kendall/Hunt Publishing Company



The fourth installment in the Global Lab series, a full-year integrated science curriculum, this unit is composed of investigations focused on air. Each investigation requires teams of students to tackle different aspects of the exploration. An online workspace permits students to upload their own data and download data collected by participating schools, allowing classes to place their local findings into a global perspective. The series includes a curriculum guide explaining how to implement these online features in the classroom. The guide also presents an overview of additional curriculum issues, including the possibility of portfolio and group assessment. For one investigation on airborne particles, students collaborate on assignments focused on topics such as biological contaminants, pollution, and dust. Teams construct various instruments, such as a particle collector made from index cards and petroleum jelly, and practice their data-collection techniques. After collection, data are recorded in the online database and students can access data from around the country. The teacher's guide contains specific learning objectives for the investigation and supplemental articles on urban air and Arctic haze. (Author/GAB) ENC-020474

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Kendall/Hunt Publishing Company, 4050 Westmark Drive, PO Box 1840, Dubuque, IA 52004
Fax: (800) 772-9165 / Toll-free: (800) 228-0810
www.kendallhunt.com
$37.99 per teacher's guide (paperback)
$12.99 per student book (paperback)

Natural Inquirer

www.naturalinquirer.usda.gov
Grades 5-12
2001
Contributor(s): Heather Taylor and Barbara McDonald
Publisher: United States Department of Agriculture

This online science education resource journal is designed to promote critical thinking, scientific inquiry, and investigation, while helping students learn about our natural resources and the environment. The journal contains research articles from USDA Forest Service scientists. These scientific journal articles, revised to meet the needs of audiences new to the area of science, are intended to be short and easy to understand. They contain illustrations, glossaries, and hands-on activities. Articles from the Winter 2001 issue, for example, discuss soil erosion, avalanches, and the effect of climatic change on the life cycle of mountain pine beetles. Each article begins by introducing the scientist who conducted the research. The articles then present a glossary of terms, an introduction to the problem, and background information, followed by research methods, results, and the implications of the study's findings. Reflection questions are embedded within the text and the articles conclude with a related hands-on activity. Additional resources are available to educators at The Teacher's Place. The Kids Corner provides quizzes based on content presented in the articles, as well as word scrambles and reflection questions. (Author/LCT) ENC-020184

Science

Grades K-6
1995
Contributor(s): Karen D. Olsen
Publisher: Center for the Future of Public Education

The elementary science curriculum outlined in this booklet is designed to be consistent with brain research and children's cognitive development. The booklet presents a continuum of science concepts correlated to the book, *Kid's Eye View of Science*, which describes current brain research and its applications to the classroom using the Kovalik Integrated Thematic Instruction (ITI) model. According to the ITI model, the learning process begins with sensory learning experiences from which the mental pattern or concept is extracted. Students then acquire the vocabulary to represent that concept and practice real-world applications until they build a mental program. For each grade level, the book summarizes the main science idea and provides a rationale that includes how it fits into the larger picture of children's development and science as a discipline. The text summarizes target concepts and provides suggested locations for experiential learning and expected performance levels of students. For example, the main science idea for kindergarten is that observing and comparing similarities and differences is a key way to help interpret and understand our world. Related concepts include using the senses to explore the environment, utilizing tools such as rulers and magnifiers to get more information, and understanding that things in nature have different weights, sizes, and ages. Subsequent grade levels explore change, interactions between living things and the environment, and structures and systems. (Author/LCT) ENC-020303

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(253) 630-6908 / Fax: (253) 630-7215 / Toll-free: (888) 777-9827
www.books4educ.com
$7.95 per book (spiral-bound)

Science 3

Series: Science: Essential Interactions
Grades 9-12
2001
Contributor(s): Alan J. Hirsch, Bob Ritter, Donald Plumb, Edward James, Nancy Dalgarno Alldred, and Stephen Haberer

This textbook emphasizes the importance of understanding science in terms of everyday situations through active learning experiences. The book offers a sequence of coordinated readings, laboratory exercises, and activities, in addition to extended projects that integrate multiple areas of science. The book's four units address the topics of matter, reproduction, electricity, and space. Also included is a handbook that outlines skills needed in conducting an experiment. Each unit begins with an overview of the material and a student challenge. In a sample chapter on sexual reproduction and the diversity of life, students discuss whether or not genetic screening should be made widely available. In small groups, students choose one side of the issue and then discuss arguments for and against it. In a related activity, students create a karyotype chart and analyze it for any disorders. They read about a fertility specialist in the unit's career profile. Color photographs, figures, and tables illustrate the text throughout. (Author/LEB) ENC-020791

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Centre Pointe Learning, Suite 1, 4305 Muhlhauser Road, Fairfield, OH 45014
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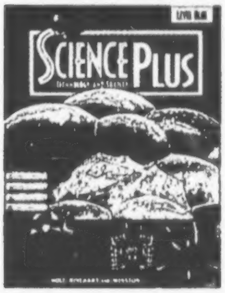
$29.95 per Text, Teachers Guide 2
$29.95 per Text, Teachers Guide 3
$29.95 per Text, Teachers Guide 4
$19.95 per Text, Curriculum Resource

SciencePlus: Level Blue

Grades 8-9
2002
Contributor(s): Alan Moore, Charles McFadden, Earl S. Morrison, Elinor Nicoll, John Haysom, Muriel Smyth, Nan Armour, and Robert E. Yager



Developed for the third year of an integrated middle school science program, these books compose the 2002 edition of SciencePlus. The program uses a variety of hands-on activities as well as textbook simulations, historical inquiries, puzzles, and data interpretation. These elements encourage students to respond to experiments the way scientists would: they observe, develop hypotheses, test their conclusions, and discuss their results. SciencePlus also relates science to other curriculum areas through creative writing activities to stimulate critical thinking, promote communication skills, and enhance comprehension of scientific reading materials. The 2002 edition links each lesson to NSTA's SCILINKS web site and utilizes CD-ROMs, computer software, and other multimedia resources. The student textbook organizes content into five themes: energy, systems, structures, change over time, and cycles that emphasize the interrelationships among science, technology, and society. The annotated teacher's edition helps organize units, lessons, and materials; it also provides Unit Compression tips that suggest how to omit selected activities. In addition, the guide offers suggestions for identifying prior knowledge and misconceptions, homework options, and assessment strategies. A teacher's resource packet, transparencies, Spanish language resources, videodiscs, and CD-ROMs are also available. (Author/LCT) ENC-020470

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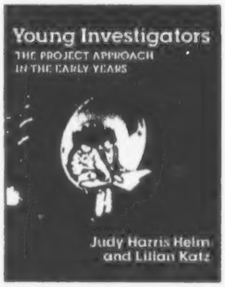
www.hrw.com
$91.20 per annotated teacher's edition (hardbound)
$52.80 per student book (hardbound)

Young Investigators

Series: Early Childhood Education
Grades PreK-1
2001
Contributor(s): Judy Harris Helm and Lilian G. Katz


Young Investigators
THE PROJECT APPROACH IN THE EARLY YEARS
Judy Harris Helm and Lilian Katz

In this book, the authors discuss the nature of project learning and explain how this pedagogical approach can be implemented in classrooms. Differences between teacher-planned experiences and project methods are explored within the text, and the academic and social benefits of project work are highlighted. Along with tips on how to get started and successfully carry out this approach, readers will find methodologies for maintaining curricular standards and utilizing technology. A sample chapter, Investigation, addresses the need for organized fieldwork. It considers logistical concerns such as proper materials, informed chaperones, and appropriate schedules, along with the more critical issues of balancing directions with spontaneity. Featured activities include doing observational sketching, developing questions, and writing results. Flowcharts and tables are included throughout to assist in developing and monitoring learning outcomes. A teacher's project planning journal is also provided. (Author/JG) ENC-019286

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For Further Exploration in Science

Ask the Experts

www.sciam.com/askexpert
Grades 6-12
2001
Contributor(s): Scientific American

At this web site, visitors can ask questions concerning specific phenomena in science, mathematics, and technology. *Scientific American* then forwards these queries to experts in both academia and industry. Questions range from why hair turns gray to what happens when lightning strikes an airplane. Due to the volume of queries received, replies cannot be made to individuals. Rather, the most interesting exchanges are posted on the site. The site does warn that homework questions and requests for general information will not be considered. One geology entry asks why the Earth's core is so hot and how scientists measure its temperature. Quentin Williams, associate professor of Earth Sciences at UC Santa Cruz, responds by describing three reasons for the core's high temperature: heat from when the planet was formed, frictional heating, and heat from the decay of radioactive elements. He goes on to outline some of the reasons scientists have trouble determining temperatures deep within the Earth. A second response is added from Gregory

Lyzenga, associate professor of physics at Harvey Mudd College. Lyzenga provides some additional details on estimating the temperature of the Earth's core. A diagram of a cross-section of the Earth is given along with a related link to a web site on the Earth's interior. (Author/GAB) ENC-020958

Case Studies in Science

ublib.buffalo.edu/libraries/projects/cases/ubcase.htm
Grades 9 and up
2001
Contributor(s): National Center for Case Study Teaching in Science
Publisher: State University of New York (SUNY), Buffalo

The case studies collected on this web site are designed to be used in undergraduate science classrooms. The goals are to "humanize" science, to illustrate scientific methodology and values, and to develop students' skills in group learning, speaking, and critical thinking. Topics include chemistry, ecology, physics, engineering, medicine, and molecular biology. In a sample case, parents must decide whether to enroll their son in a clinical trial for an experimental muscular dystrophy treatment. To help these parents make their decision, students study normal muscle function and the genetics of X-linked inheritance. Another case study allows students to work cooperatively as they explore the scientific, technical, environmental, and ethical issues related to the possibility of cloning dinosaurs from DNA extracted from fossilized dinosaur remains. The cases employ both open-ended formats, in which there is no one answer, and directed formats, in which a story includes a number of questions about the case. Case teaching notes summarize learning objectives and provide guidelines for case analysis, classroom management tips, and additional background information. (Author/LCT) ENC-019214

Inquiring into Inquiry Learning and Teaching in Science

Grades K-12
2000
Contributor(s): Emily H. van Zee and James A. Minstrell

This book presents contributions on the topic of inquiry learning from scientists, educators, and education researchers. Each author defines his or her notions of inquiry teaching and learning and then addresses a relevant issue in the context of his or her own practices. The book specifically includes authors who work with students from diverse cultural and socioeconomic circumstances. In the first section, scientists and science education leaders reflect upon what inquiry means and why it should be emphasized in school science. The second section presents examples of inquiry teaching and learning in several contexts, including classrooms, professional development programs, and college science courses. The final section addresses such issues as technology support for inquiry, metacognitive strategies, and learning assessment. An epilogue synthesizes the ideas put forward by the book's authors and offers a summary of lessons learned about inquiry. (Author/GAB) ENC-020086

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Leveraging Learning

ll.terc.edu/
Series: TERC Kids Network.
Grades: 2-8
2001
Contributor(s): Judy Vesel
Publisher: TERC

The science curriculum units at this web site integrate hands-on investigations with online inquiries. Activities for reading, writing, and communicating incorporate the featured science content and provide embedded assessments. Units supplement a core science curriculum and incorporate online data sharing and analysis. A printable teacher's guide and student reproducible worksheets are provided for each unit. Lab supplies can be ordered online. Each unit focuses upon a central question that leads to exploration of the science content and related environmental and social issues. For example, one unit seeks to answer the question: Are we getting the oxygen we need? In this unit, students study the connection between the circulatory and respiratory systems by reading online articles, conducting laboratory exercises, and examining color illustrations that provide background information about the subject. Students collect and analyze data regarding aerobic exercise and then submit it to a database for comparison. Social and health issues are tied to the lesson as students critically analyze the effect of diet and cigarette smoking on the respiratory and circulatory systems. Students also consider environmental factors such as air quality. (Author/LEB) ENC-021013

Nibbling on Einstein's Brain

Grades 5-12
2001
Contributor(s): Diane Swanson and Warren Clark
Publisher: Annick Press

Nibbling on Einstein's Brain

This book provides readers with strategies for evaluating the credibility of scientific claims. The authors explore the difference between bad science and good science as well as the ways in which data can be manipulated to present a biased picture of events. Baloney Busters challenge claims, analyze the analysis of data, and question conclusions presented in a variety of media formats. Throughout the text, sidebar features provide critical thinking scenarios and summarize key concepts. A sample chapter, Mind Watch, discusses how personal perceptions can cloud scientific reality. Issues such as gossip, self-esteem, and opinions are addressed, along with the importance of staying grounded in science literacy. An activity encourages students to gather at night with friends and tell spooky stories to determine if the context affects how people interpret what they see and hear. Additional text helps readers cope with scientific information that conflicts with their own assumptions. (Author/JG) ENC-020874

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Practicing Science

Grades 11 and up
2001
Contributor(s): National Science Teachers Association
Publisher: NSTA Press

This journal reveals the teaching techniques of science professors practicing the inquiry method in college and university classrooms. The collection includes ten first-person articles, selected from the *Journal of College Science Teaching*, which illustrate both how investigative learning contributes to the goal of scientific literacy and why the inquiry method should be a part of every college student's experience. Contact information for each author is provided. In a traditional science classroom, learning proceeds from the abstract to the concrete. Concepts are introduced first and applications follow. In problem-based learning, students are first presented with a real-world problem. They experience the process of doing science as it is actually practiced. In an example problem from the physics course, students are given a police report written at the scene of an automobile accident. They are then asked to gather all pertinent information and determine which driver was at fault. (Author/LEB) ENC-020330

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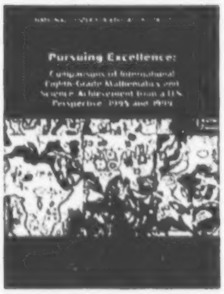
Pursuing Excellence

Grades 6-9
2001
Contributor(s): Christopher Calsyn, David Kastberg, Kitty Mak, Leslie Jocelyn, Patrick Gonzales, Sousan Arafeh, Trevor Williams, and Winnie Tsen



This report contains the initial findings from the Third International Mathematics and Science Study--Repeat (TIMSS-R). The study was conducted in 1999, four years after TIMSS, and was designed to focus on the mathematics and science achievement of eighth grade students. The report, compiled by the National Center for Education Statistics (NCES), presents initial findings on how eighth grade students in the United States fared on TIMSS-R and whether there have been significant changes in achievement in the four years since TIMSS. An introductory chapter provides background information on why and how TIMSS-R was conducted, as well as its relationship to TIMSS. Next, the initial findings of the study in mathematics and science achievement are presented, followed by the initial findings on teaching and curriculum. The report concludes with suggestions for future directions in light of lessons learned from TIMSS and TIMSS-R. A series of appendices contain the supporting data for the discussion and conclusions in the chapters. (Author/MM) ENC-019295

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$0.00 per book (paperback)

Science as Inquiry in Action

Series: Schlessinger Science Library
Grades 5-8
2000
Contributor(s): Andrew Schlessinger and Tracy Mitchell

In this video, a boy named Kevin struggles to come up with an idea for his science project. Through the course of the program, viewers learn about the components of a scientific investigation. During Kevin's search for a topic, he is assisted by world-renowned scientists Benjamin Franklin, Marie Curie, and George Washington Carver. The accompanying teacher's guide includes an introduction to science as inquiry, a program summary, and vocabulary list, as well as follow-up questions, activities, and resources. A magic dry-erase board records important terminology as it is introduced throughout the video. In one segment, Kevin shares his idea of exploring how electrical energy can be created in a clean and safe way. Marie Curie leads Kevin through an experiment testing an alternative source of electricity, which involves transforming a lemon into a battery. The trio of scientists applauds Kevin's achievement and reminds him of the importance of scientific inquiry. In a suggested follow-up activity, students design and conduct their own original investigations that have been critiqued first by their peers. (Author/LEB) ENC-021163

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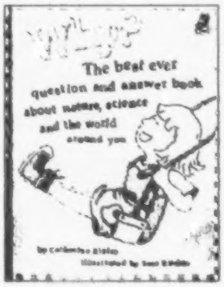
Why?

Grades PreK-3
2001
Contributor(s): Scot Ritchie and Catherine Ripley
Publisher: Owl Books



In this book, students will find short answers to an assortment of frequently asked questions regarding science, nature, and the world around us. Questions are grouped according to the context in which they might be asked; for example, section headings include the kitchen, the supermarket, and the outdoors. Queries range from why some eggs are brown and some white, to why we can't see just after the lights are turned off. As an example, the text answers the question, "Why do my fingers stick to the frozen juice cans?", with an explanation of how moisture on our fingertips freezes when we touch a frozen surface. An illustration shows a mother and child at the frozen-foods section of the supermarket, with a can of frozen juice stuck to the fingers of the child. (Author/GAB) ENC-020896

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It's Summer! Time for Your Own Professional Learning!

Most of you probably didn't have time to really explore *By Your Own Design: A Teacher's Professional Learning Guide* when you received the CD with the January issue of *ENC Focus*. Perhaps you have more time this summer, so here are three ways to dive into this information-packed resource:

1. Set goals for yourself. The front page of the CD offers a link to Develop a Learning Plan, which contains worksheets and information to get you started.
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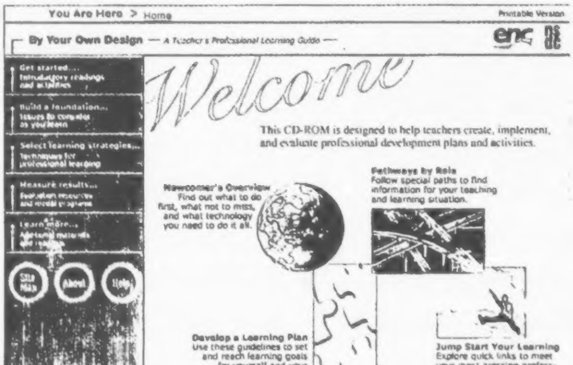
3. Find two colleagues and investigate a new learning strategy together. Link to Select Learning Strategies to find 10 different avenues for learning.



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